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VOL. 101. 1950.

FURTHER STUDIES ON THE RELATION OF HUMIDITY AND TEMPERATURE TO THE DEVELOPMENT OF TWO SPECIES OF AFRICAN LOCUSTS –*LOCUSTA MIGRATORIA MIGRATORIOIDES* (R. & F.) AND *SCHISTOCERCA GREGARIA* (FORSK.).

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(*Biological Department, St. Thomas's Hospital Medical School, London, S.E.*1.)

Manuscript received 19th April, 1949.

(Read 7th December, 1949.)

WITH 34 TEXT-FIGURES.

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I. INTRODUCTION.

THIS work is a continuation of that which I published in 1936, and its purpose is:

(1) To give a more complete and precise account of the factors which influence the development and multiplication of locusts.

(2) To show the effect of alternating humidities and temperatures on the life-cycle.

(3) To establish a connection between laboratory and field results.

The publication of 1936 gives the preliminary results of experiments carried out under constant conditions of humidity and temperature. It was published in order that the then available knowledge could be used by those working on locusts in the field. In the interval additional experiments have been carried out, and these are now added to those already published. The combined results give a comprehensive picture of the effect of constant humidity and constant temperature on the life-cycle of two species of African locusts (*Locusta migratoria migratorioides* Reiche & Fairmaire and *Schistocerca gregaria* Forskål). Since it is important to understand the effect of constant conditions, before proceeding to the study of alternating conditions, it is necessary to give a short account of these findings. This is especially so because it has been possible (see below) to produce equations showing the effect of temperature on the life-cycle when humidity is at the optimum.

Detailed accounts of the life-cycles, under natural conditions, have been given for *Locusta migratoria* by Allan 1932, Johnson and Maxwell-Darling 1931, Lean 1931, 1931*a*, Uvarov 1928, 1933, 1933*a*, 1934, 1935, Uvarov and Milnthorpe 1937, 1937*a*, 1938, and Zolotarevsky 1933, 1938, and for *Schistocerca gregaria* by Ballard, Mistikawi and Zoheiry 1932, Donnelly 1947, Maxwell-Darling 1934, 1936, 1937, Rao 1939, 1942, Uvarov 1928, 1933, 1933*a*, 1934, 1935, Uvarov and Milnthorpe 1937, 1937*a*, 1938, Waloff 1946, Zolotarevsky, de Lepiney and Dupont 1934.

The locusts used in all the experiments were of the phase *transiens*, and from the same stock as those used in the experiments published in 1936. All experiments were carried out in the same apparatus as described in that paper, and the same method of drying the food was employed. Dried food was supplied to all stages except first and second instar hoppers.

My sincere thanks are offered to Dr. B. P. Uvarov for his advice and encouragement at all stages of the work.

I would like to express my indebtedness to Professor J. B. Buxton, Royal Veterinary College, London, for permitting me to continue this work after joining the College staff. Finally I would like to thank my colleagues on the staff of the Anti-Locust Research Centre (formerly part of the Imperial Institute of Entomology), especially Mr. S. T. P. Brightwell and Miss Z. Waloff, for their help and co-operation, and the Engineers of His Majesty's Office of Works for assistance in overcoming technical difficulties.

II. THE EFFECT OF CONSTANT CONDITIONS OF HUMIDITY AND TEMPERATURE ON THE DEVELOPMENT OF HOPPERS.

(a) *Locusta.*

The effect of humidity on the rate of development of *Locusta* hoppers at several temperatures, i.e. at 75° F. (23·9° C.), 80° F. (26·7° C.), 90° F. (32·2° C.), 100° F. (37·8° C.) and at 110° F. (43·3° C.), is shown in Table I and fig. 1. It is possible to breed successive generations at all the above constant temperatures without any deleterious effect, except at 110° F., at which temperature the fecundity of the adults is affected (see below). Because of this it was necessary to start these experiments with hoppers from eggs laid at temperatures not exceeding 100° F.

TABLE 1.

Table showing the effect of humidity on the development of *Locusta* hoppers at different temperatures.

Number of experiments.	Temperature.	Relative humidity.	Number of hoppers at start of experiment.	Length of hopper life (days).			Number of hoppers to reach adult stage.		Percentage of hoppers to reach adult stage.
				Average.	Min.	Max.	♂♂.	♀♀.	
1	75° F. (23·9° C.)	60	31	38·5	35	41	7	8	48·4
1		70	25	40·3	37	42	4	7	44·0
1		75	37	44·7	41	52	14	6	54·1
1		85	36	46·3	42	54	3	4	19·2
1	80° F. (26·7° C.)	25	52	All dead by 7th day			0	0	0·0
4		35	342	39·5	32	45	24	28	15·2
1		50	81	34·9	29	36	19	17	44·4
1		65	35	32·3	28	34	12	14	74·0
3		70	106	33·6	27	47	36	28	60·4
3		75	174	39·0	33	48	44	44	50·6
2		80	105	44·2	38	51	16	19	33·3
3		85	212	45·4	40	56	11	16	12·7
2		95	93	All dead by 8th day			0	0	0·0
1	90° F. (32·2° C.)	25	27	All dead by 23rd day			0	0	0·0
3		35	149	38·8	24	47	19	16	23·5
2		40	76	38·0	35	44	12	11	30·3
1		45	32	32·4	30	40	3	11	43·7
2		50	88	29·4	24	35	25	18	49·0
2		55	109	28·7	24	34	32	26	53·2
3		60	133	27·3	24	34	48	42	67·7
5		65	209	27·1	22	37	68	78	74·6
7		70	295	26·6	21	36	117	113	78·0
5		75	187	28·1	22	43	65	65	69·5
4		80	190	32·8	25	36	46	51	51·1
2		85	129	38·5	36	43	5	10	11·6
1		95	35	All dead by 5th day			0	0	0·0
1	100° F. (37·8° C.)	35	51	All dead by 4th day			0	0	0·0
1		45	57	29·7	25	34	3	3	10·5
1		50	44	26·1	21	32	7	7	31·8
1		55	32	25·7	23	30	10	6	50·0
2		60	52	23·6	22	27	16	15	59·6
3		65	51	23·2	19	26	16	22	74·5
6		70	327	22·9	20	30	119	104	68·2
2		75	156	28·5	22	40	40	48	56·4
1		80	39	29·3	27	32	7	6	33·3
2		85	145	31·0	26	36	22	26	31·2
1		95	13	All dead by 7th day			0	0	0·0
1	110° F. (43·3° C.)	40	58	All dead by 6th day			0	0	0·0
1		55	39	23·3	23	24	3	1	10·3
2		60	55	20·9	19	24	10	8	32·7
4		65	191	19·9	17	27	40	48	46·1
1		70	56	19·8	17	24	7	6	23·1
2		75	101	24·2	22	27	15	12	26·7
1		80	73	26·6	24	28	5	3	9·6
1		85	47	All dead by 9th day			0	0	0·0

A point to be observed from the curves (fig. 1) is the different effect of humidity at different temperatures. For example, the optimal rate of hopper development (i.e. shortest time required to reach the adult stage) at 110° F. is at a relative humidity of 68%, whereas at 75° F. the optimal rate of development is at a relative humidity of 64%. This difference in the relative humidity required for optimal development at different temperatures is probably due to greater evaporation at the higher temperatures, and therefore a slightly higher relative humidity is required to enable the hoppers to maintain the water content of their bodies.

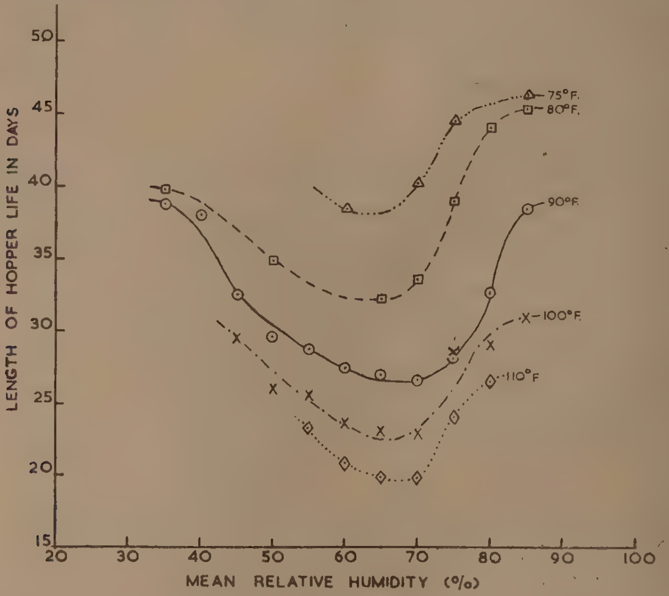

Fig. 1.—The effect of relative humidity at different constant temperatures on the time required for development of *Locusta* hoppers.

An examination of the curves showing the effect of relative humidity at different temperatures (fig. 1) reveals that the rate of development gradually decreases as the humidity becomes less favourable. This is to be expected, but the curves also show that the change in the rate of development at the lower temperatures is gradual, whereas at the higher temperatures it is more marked. Further, the range of relative humidities at which it is possible for development to occur is reduced (at both upper and lower limits) as the temperature is increased (Table 1). Taking the lowest temperature (80° F.) where the upper and lower limits of relative humidity are known, it can be seen that hoppers develop, and adults emerge, at relative humidities ranging from 35% to 85%, whereas at the highest temperature (110° F.) adults emerge only at relative humidities between 55% and 80%. These curves also illustrate that

TABLE 2.

Table showing the effect of humidity on the development of *Schistocerca* hoppers at different temperatures.

Number of experiments.	Temperature.	Relative humidity.	Number of hoppers at start of experiment.	Length of hopper life (days).			Number of hoppers to reach adult stage.		Percentage of hoppers to reach adult stage.
				Average.	Min.	Max.	♂♂.	♀♀.	
1	80° F. (26·7° C.)	25	41	All dead by 4th day			0	0	0·0
2		35	96	42·5	41	46	3	3	6·3
1		45	45	38·0	36	40	4	5	20·0
1		55	42	35·0	32	37	7	9	38·1
2		60	70	34·0	31	38	17	15	45·6
1		65	48	33·8	31	38	10	13	47·9
1		70	35	33·7	31	37	7	8	42·9
2		75	89	35·9	34	37	13	12	28·0
2		85	284	38·1	32	41	18	13	10·9
1	90° F. (32·2° C.)	35	38	All dead by 3rd day			0	0	0·0
2		45	74	29·7	27	32	5	11	21·6
3		50	103	29·8	26	33	15	21	35·0
2		55	69	28·1	24	32	16	14	43·3
2		60	63	27·6	26	32	14	19	52·4
3		65	135	27·2	25	30	41	51	68·1
5		70	133	27·8	24	31	32	45	57·9
4		75	176	32·2	25	36	30	27	32·4
4		80*	213	34·8	33	41	4	9	6·1
3		85	141	All dead by 27th day			0	0	0·0
1		90	13	All dead by 4th day			0	0	0·0
1	100° F. (37·8° C.)	35	43	All dead by 3rd day			0	0	0·0
2		45	86	29·3	27	31	5	3	9·3
2		50	72	27·3	24	30	13	12	34·7
2		55	69	25·1	22	29	19	17	52·2
1		60	61	24·7	22	28	18	17	57·4
2		65	64	24·4	21	28	22	19	63·4
3		70	141	23·9	21	28	33	26	41·9
3		75	143	25·6	24	29	16	13	20·3
1		80	43	All dead by 23rd day			0	0	0·0
2		85	54	All dead by 7th day			0	0	0·0
1	110° F. (43·3° C.)	60	74	26·5	24	28	13	7	27·0
1		65	15	24·7	24	26	2	4	40·0

* In one of the experiments none of the hoppers ever reached the adult stage (all dead by 18th day).

the rate of development does not go on decreasing as previously suggested (Hamilton, 1936), but tends to become almost constant, and so the curves flatten out towards the upper and lower limits of relative humidity. In order to appreciate this fully, it is necessary to compare the curves showing the rate of development with those showing the percentage of hoppers which reach the adult stage (fig. 2), when it will be seen that under very unfavourable conditions death occurs, rather than a retardation of growth. Humidity, though a secondary factor to temperature, is therefore of great importance for the development of locust hoppers. Fig. 2 also shows that at any given relative humidity a higher percentage of hoppers reach the adult stage at 90° F. than at any other temperature. While it is true that the curves, showing the percentage of hoppers which reach the adult stage at 80° F. and 100° F., lie entirely within the curve at 90° F., it should be noted that these two curves do not conform to each other, but cross, approximately at their optimal points (i.e. between 60% and 65% relative humidity). At any given relative humidity below these optimal points the curve for 80° F. shows a higher percentage of hoppers reaching the adult stage than does the curve for 100° F., whereas above these optimal points the relationship is reversed. The curve for 110° F. lies well within all the others, as it is restricted to a very small variation above and below the optimum. All relative humidities at this temperature give a much lower percentage of hoppers than at any other temperature. These facts show that a temperature which produces a fast rate of hopper development cannot always be regarded as a favourable one. At all temperatures an increase in the humidity above the optimum has a more marked effect upon the rate of development of hoppers (fig. 1), and on the percentage which become adult (fig. 2), than has a corresponding decrease below the optimum.

Since the effect of temperature on the rate of development is closely linked with relative humidity, the only results which may be used, when comparing the effect of different temperatures, are the optimal points shown by the humidity curves at the different temperatures, and they (Table 3) must therefore be taken as showing the effect of temperature on the rate of development. These results are quite normal, as the slowest rate of development occurs at 75° F. and the fastest at 110° F. By making use of mathematical calculations it is possible to extend these experimental results, since they approximate closely to the curve L (fig. 3) produced from the equation $(x - 53)(y - 9) = 635$. (In this equation x represents temperature in ° F., and y the time, in days, required by hoppers to reach the adult stage.)

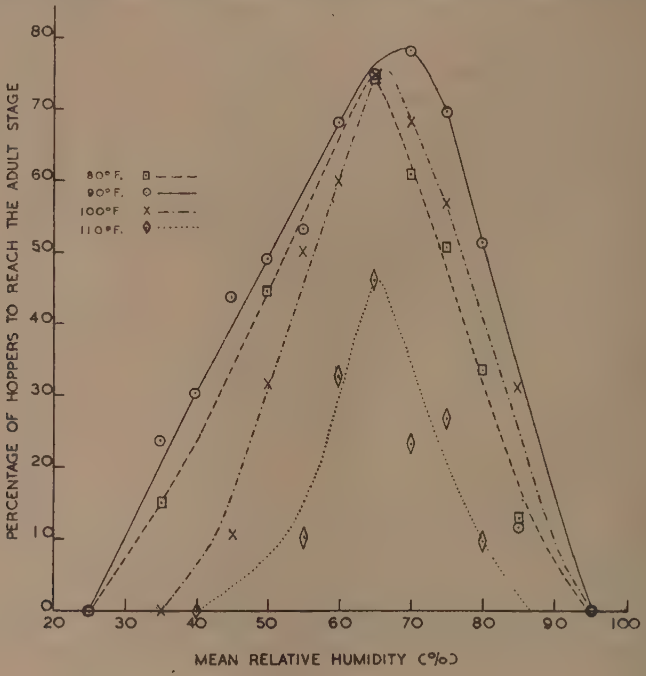

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Fig. 2.—The effect of relative humidity at different constant temperatures on the percentage of *Locusta* hoppers reaching the adult stage.

This indicates that, for *Locusta*, the minimum developmental threshold is 53° F. (11·7° C.), and that the theoretical shortest possible time required for

TABLE 3.

Table giving the theoretical times required for hopper development (from the equations) at different temperatures and the corresponding experimental results (where available).

Locusta.

Temperature, ° F. (x).	Theoretical time (y), in days, from equation $(x-53)(y-9)=635$.	Experimental results from curves in fig. 1 (in days).
70	46·4 days	— days
75	37·9 ,,	38·0 ,,
80	32·5 ,,	32·2 ,,
90	26·2 ,,	26·3 ,,
100	22·5 ,,	22·7 ,,
110	20·1 ,,	19·5 ,,
120	18·5 ,,	— ,,
130	17·3 ,,	— ,,

Schistocerca.

Temperature, ° F. (x).	Theoretical time (y), in days, from equation $(x-63)(y-16)=300$.	Experimental results from curves in fig. 6 (in days).
70	58·8 days	— days
75	41·0 ,,	— ,,
80	33·6 ,,	33·5 ,,
90	27·1 ,,	27·1 ,,
100	24·1 ,,	24·1 ,,
110	22·4 ,,	24·5 ,,
120	21·3 ,,	— ,,
130	20·5 ,,	— ,,

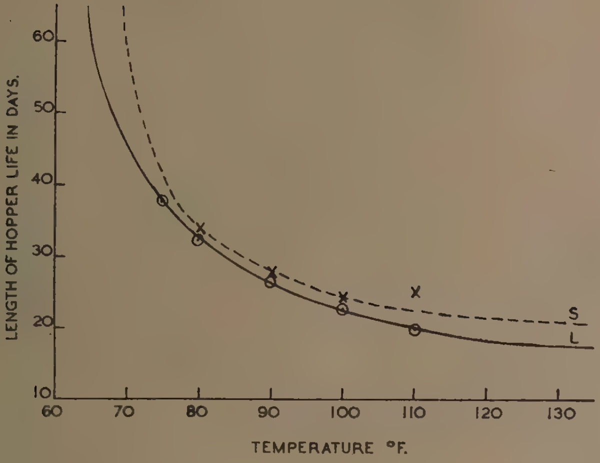

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FIG. 3.—Curves showing how the effect of temperature on the development of hoppers can be applied to curves produced from formulae. Curve L, drawn from formula $(x - 53)(y - 9) = 635$, with the experimental results for *Locusta* indicated ⊙. Curve S, drawn from formula $(x - 63)(y - 16) = 300$, with experimental results for *Schistocerca* indicated ×. (In the equations x = temperature in ° F., y = length of hopper life in days. For details see Table 3.)

hopper development is 9 days. Although 53° F. (11·7° C.) is the minimum constant temperature at which development proceeds it is not cold enough to be lethal, as hoppers are able to survive, for a time, at much lower temperatures. In a few experiments carried out by me it was found that development occurred and adults emerged, provided that the low temperature, which was below the developmental zero, alternated with a suitable higher temperature above the developmental zero. In my experiments the hoppers were kept at 90° F. (32·2° C.) during the day and at 35° F. (1·7° C.) during the night. Hussein (1937) in work on *Locusta* found that hoppers which had been kept at 32° (0° C.) and 34° F. (1·1° C.) for 15 hours behaved normally when the temperature was increased to a suitable one above the developmental zero. Further, he found that exposure to this low temperature could be extended to 45 hours without causing death, but the recovery period was longer than in the case of exposure for 15 hours.

To obtain the maximum rate of development given by the equation it would require a temperature very much higher than hoppers could possibly withstand. The optimal rate of development for *Locusta* hoppers occurred at 110° F. (i.e the highest temperature tested in the experiments), and at a relative humidity of between 65% and 70%. Although there is no direct proof to show that development would not be faster at some higher constant temperature, there is indirect evidence to suggest that it is most unlikely, because the percentage of hoppers reaching the adult stage at this temperature (fig. 2) is lower than at 100° F. It is also lower than the percentage obtained at 90° F., but it must be remembered (see above) that 90° F. gives a higher percentage of adults than any other constant temperature at a corresponding relative humidity. Further, as will be seen later, the fecundity of adults is lower at 110° F. than at 90° F. Hussein found that *Locusta* hoppers showed signs of excitement due to heat when a rising temperature reached 103° F. (39·4° C.) in the case of 1st instar hoppers and 113° F. (45·0° C.) in the case of 5th instar hoppers. The other instars showed excitement at temperatures between these extremes. Also he found that activity of 1st and 5th instar hoppers was depressed by heat when temperatures reached 108° F. (42·2° C.) and 118° F. (47·8° C.) respectively. The fatal upper limit of temperature was slightly above the last mentioned range, but the length of exposure plays a part. Since I found it possible to keep hoppers of all stages, and to have adults emerging, at a constant temperature of 110° F., it is obvious that the excitement which Hussein describes is due, in part, to stimulation by a changing temperature. However, it must be admitted that 110° F. is approaching the upper limit of temperature.

While it is possible to obtain much information regarding the effect of humidity and temperature on the rate of development and on the percentage of hoppers which reach the adult stage from Table I, the most effective method of demonstrating the combined effect of humidity and temperature is by lines showing the time required for hopper development (fig. 4) and lines showing the percentage of hoppers becoming adult (fig. 5). These lines are drawn from the results given in Table 1 and are indicated in large type. The smaller figures in italic type are results obtained under alternating conditions of humidity and temperature and will be dealt with later in the paper. Fig. 4 shows that the shortest time required for the development of *Locusta* hoppers is 20 days, and

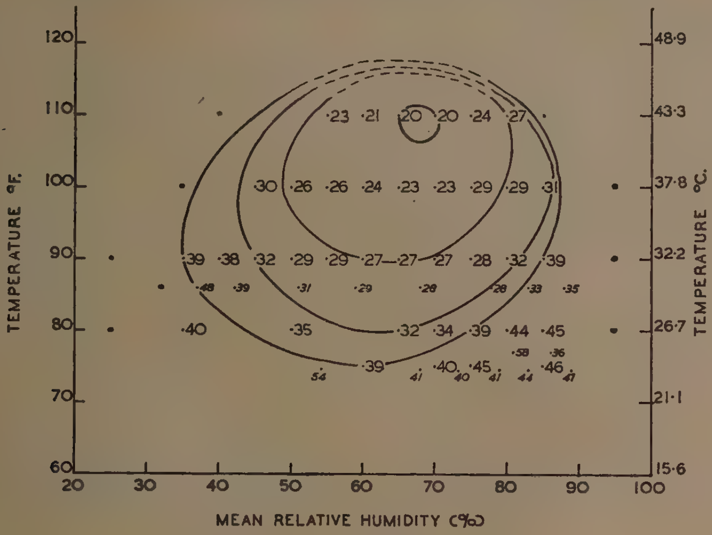

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FIG. 4.—Lines showing the time required for development of *Locusta* hoppers at different constant relative humidities and temperatures. The results for alternating relative humidities and temperatures (calculated to give weighted mean humidities and temperatures) are shown in small type, but they are not taken into account when drawing the lines.

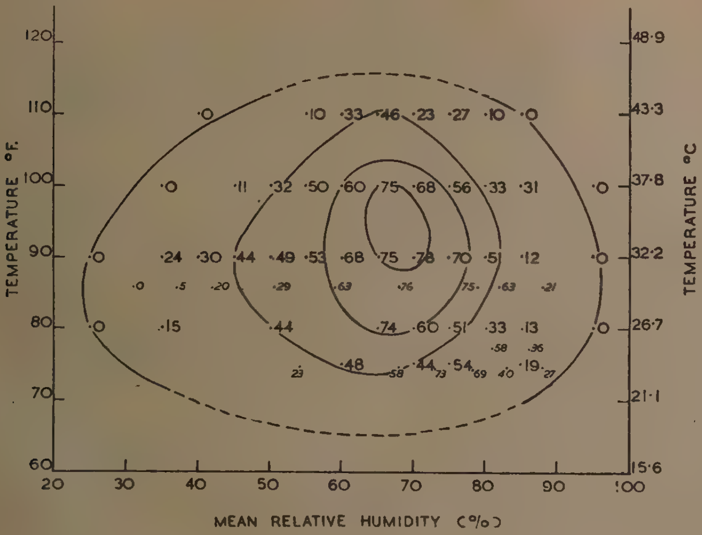

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FIG. 5.—Lines showing the percentage of *Locusta* hoppers reaching the adult stage at different constant relative humidities and temperatures. The results for alternating relative humidities and temperatures (calculated to give weighted mean humidities and temperatures) are shown in small type, but they are not taken into account when drawing the lines.

that this time for development occurs at several points. When these points are joined, bearing in mind the connection between other equal points, a circle is formed which must be regarded as surrounding the optimal point. As conditions become less favourable the lines of equal times of development form larger circles, until conditions are reached when development is so reduced that all hoppers die before reaching the adult stage. It should be noted that the minimum time required for development occurs over a very small variation of temperature close to 110° F. and between 65% and 70% relative humidity. Another important point is the way the lines connecting points of equal times for development at 110° F., 100° F., 90° F. and 80° F. converge, thus suggesting (as shown by broken lines) that they meet at a point slightly above the 110° F line. This adds more proof to the assumption that 110° F. is close to the upper limit of temperature.

In fig. 5, which shows lines of percentage of hoppers reaching the adult stage, the optimal point is well within the range of temperatures and humidities at which experiments were conducted. The highest percentage, which occurs at several points, is 75%. The line connecting these points forms a closed curve which extends from below 90° F. to above 100° F., but does not, anywhere, approach the 110° F. line. The humidity range is from 65% to 70%. This curve has within it a point on the 90° F. line where 78% reach the adult stage, but taking everything into consideration it would appear that the optimal point would be at a temperature between 90° F. and 100° F. and at a relative humidity within the range stated above. Passing to less favourable conditions, the curves increase in length until at the outer limit no hoppers ever reach the adult stage.

(b) *Schistocerca.*

Turning to *Schistocerca*, Table 2 and fig. 6 show that the effect of relative humidity on the rate of development of hoppers at the following constant temperatures of 80° F. (26·7° C.), 90° F. (32·2° C.), 100° F. (37·8° C.) is much less marked around the optimum (65%) than in the case of *Locusta*. Unfortunately no experiments were carried out at 75° F. (23·9° C.), and the number of experiments completed at 110° F. is insignificant for a true comparison of the effect of humidity to be made, but they do, however, show the effect of temperature on the rate of development and on the percentage of hoppers reaching the adult stage. Assuming a slightly shorter time for development (say 24·5 days to reach the adult stage) at perhaps a relative humidity of 70%, instead of the 24·7 days at 65% relative humidity, the developmental rate would still be below the optimum for 100° F. Comparing the effect of humidity on the rate of development at 80° F., 90° F. and 100° F., it will be seen that the optimal relative humidity for the different temperatures shows a less marked increase, with rise in temperature, than in the case of *Locusta*. The range of relative humidity at which it is possible to rear hoppers to the adult stage is reduced with rise in temperature. At 80° F. *Schistocerca* hoppers reach the adult stage at all relative humidities between 35% and 85%; which is the same as for *Locusta* hoppers, but with an increase in temperature to 100° F. the range is from 45% to 75% for *Schistocerca*, which gives a lower upper limit than the 45% to 85% range for *Locusta* at the same temperature. At 100° F. and 35% relative humidity all *Schistocerca* hoppers died within the first three days, compared with four days for *Locusta*, thus the lower limit is approximately the same for both species. Also at 90° F. all *Schistocerca* hoppers died within the first few days after hatching when kept at relative humidity of 35%, and it was not until the temperature was reduced to 80° F. that hoppers succeeded in reaching the adult stage at 35% relative humidity. The curves (fig. 6), showing the effect of humidity at different temperatures, become flattened at the upper and lower limits of humidity as the rates of development become more constant. This is very similar to the results for *Locusta*.

On examining the effect of relative humidity on the percentage of *Schistocerca* hoppers reaching the adult stage, it will be seen (Table 2 and fig. 7) that no one temperature gives a higher percentage at all relative humidities as occurred in the case of *Locusta* hoppers at 90° F. (*cf*. fig. 2). The percentage of *Schistocerca* hoppers reaching the adult stage at 90° F. is higher at relative humidities between approximately 50% and 75% than at any of the other temperatures. Below 50% and above 75% relative humidity 80° F. gives a higher percentage than any of the other temperatures. The curve for 100° F. lies, at all humidities, within the one for 90° F. Around the optimal humidity the 100° F. curve gives a higher percentage than the 80° F., but at the more unfavourable humidities the relationship is reversed. The two results at 110° F. (not shown in fig. 7) lie well within all the other curves, as they give 27% and 40% adults at 60% and 65% relative humidity respectively. This shows that the humidity range decreases with rise in temperature.

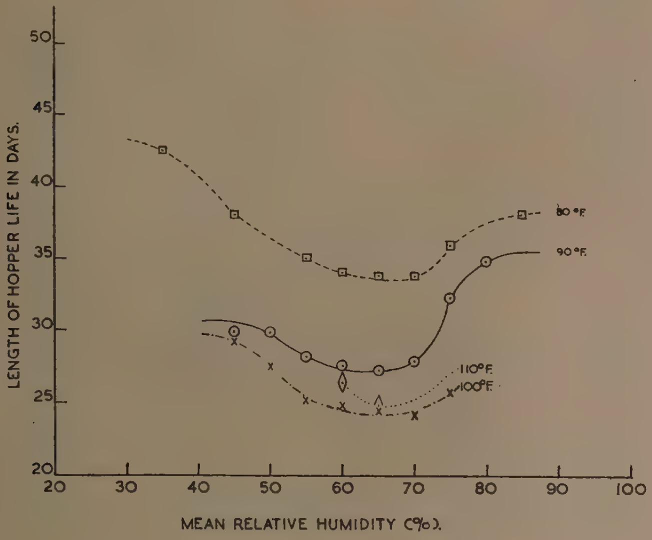

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Fig. 6.—The effect of relative humidity at different constant temperatures on the time required for development of *Schistocerca* hoppers.

The only authentic figures showing the effect of temperature on *Schisto-*

cerca hoppers are those obtained from the curves showing the effect of relative humidity at 80° F., 90° F. and 100° F. The optimal rate of development at each temperature is given in Table 3, and must be taken as showing the effect of temperature. Only two experiments were carried out at 110° F., and the results show that at this temperature the rate of development was slower than at 100° F. at the same relative humidities. At 110° F. the shortest time required for development (24·7 days) occurred at 65% relative humidity, and it is safe to assume, judging from the trend of the curve, that development would be slightly slower at 70% relative humidity. Above this humidity the time required for development increases, so it may be taken that at the optimal rate of development at 110° F. the time required would be approximately 24·5 days. Since this is longer than the time required for development at 100° F., the results suggest that the optimal temperature is well below 110° F. This hypothesis is further supported by a comparison of the rates of development for the two species; at 80° F., 90° F. and 100° F. *Schistocerca* hoppers require approximately one day longer to reach the adult stage than *Locusta* hoppers, whereas at 110° F. the difference is 5 days. Because of this difference the results at 110° F. cannot be used when calculating an equation for temperature.

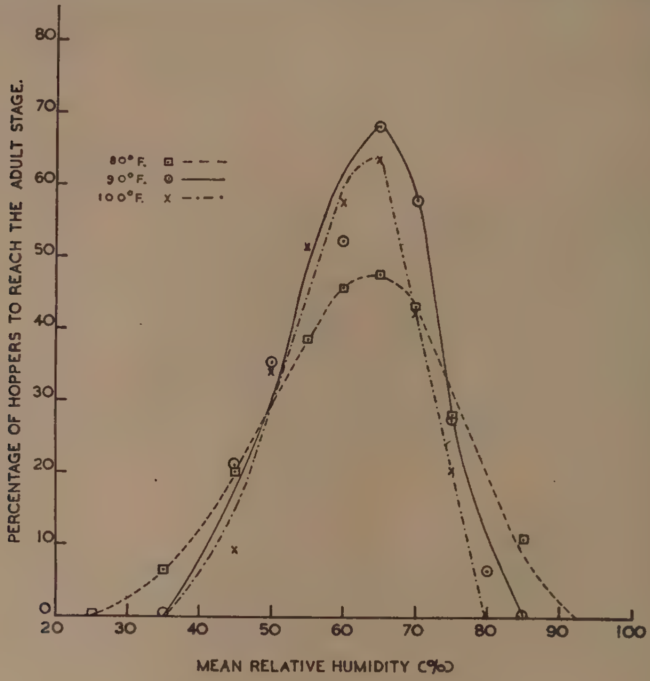

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Fig. 7.—The effect of relative humidity at different constant temperatures on the percentage of *Schistocerca* hoppers reaching the adult stage.

The equation for *Schistocerca* which coincides with the experimental results is $(x - 63)(y - 16) = 300$, represented by curve s in fig. 3. This indicates that no development takes place at temperatures below 63° F. (17·2° C.), and that 16 days is the theoretical shortest possible time required for development, as compared with a temperature of 53° F. (11·2° C.) and 9 days for *Locusta*. This minimum temperature of 63° F. for the development of *Schistocerca* hoppers is, as in the case of *Locusta*, not the minimum for survival if exposure is only for a short period. In a few experiments which I carried out hoppers were kept at 90° F. (32·2° C.) during the day and at 35° F. (1·7° C.) during the night, and a reasonable percentage reached the adult stage. Hussein (1937) found similar results for *Schistocerca* as for *Locusta*, when cooling below normal temperature conditions. Ballard, Mistikawi and Zoheiry (1932) record hoppers surviving at mean minimum temperatures as low as 40·8° F. (4·9° C.). When increasing the temperature above normal, Hussein found that *Schistocerca* displayed signs of discomfort (i.e excitement due to heat) at approximately the same temperature as *Locusta* hoppers; for example, 1st instar hoppers at 105° F. (40·6° C.) and 5th instar hoppers at 113° F. (45° C.). When the temperature was further increased he found that *Schistocerca* became paralysed at 115° F. (46·1° C.), which is at a lower temperature than in the case of *Locusta*, where it occurred at 119° F. (48·3° C.). These results all show that *Schistocerca* hoppers have a more limited range of temperature, as well as humidity, than *Locusta*.

The combined effect of humidity and temperature on *Schistocerca* hoppers is best illustrated by lines showing the time required for hopper development (fig. 8) and lines showing percentage of hoppers becoming adult (fig. 9). The lines are drawn from the results obtained under constant conditions of humidity and temperature (Table 2). As in the case of *Locusta* results they are indicated in large type; those in small italic type represent results under alternating conditions and will be considered later. Because of the fact that 110° F. is approaching the upper limit of temperature, these curves give more convincing evidence of the effect of temperature than did the *Locusta* curves. The minimum time for development (24 days) for this species occurs on the 100° F. line at relative humidities of 65% and 70%. Surrounding this comes the 25-day line, which extends from above 80° F. to 110° F. and from 55% to 70% relative humidity, and shows that the optimal temperature is definitely below 110° F. Thus in this species the lines for length of hopper life definitely converge and meet above the optimal point. In the case of the lines showing the percentage of hoppers reaching the adult stage (fig. 9) the optimum is at 90° F. and 65% relative humidity, where 68% of the hoppers reached the adult stage. This is the same temperature as that at which the maximum number of *Locusta* hoppers reached the adult stage, but at a lower relative humidity. Around this optimum are the other percentage lines, which gradually increase until the stage is reached when no hoppers ever become adult.

III. THE EFFECT OF ALTERNATING HUMIDITIES AND TEMPERATURES ON THE DEVELOPMENT OF HOPPERS.

Having obtained comprehensive records of the effect of constant humidities and temperatures on the development of hoppers, it seemed possible that alternating conditions, resembling to a certain extent natural conditions, might

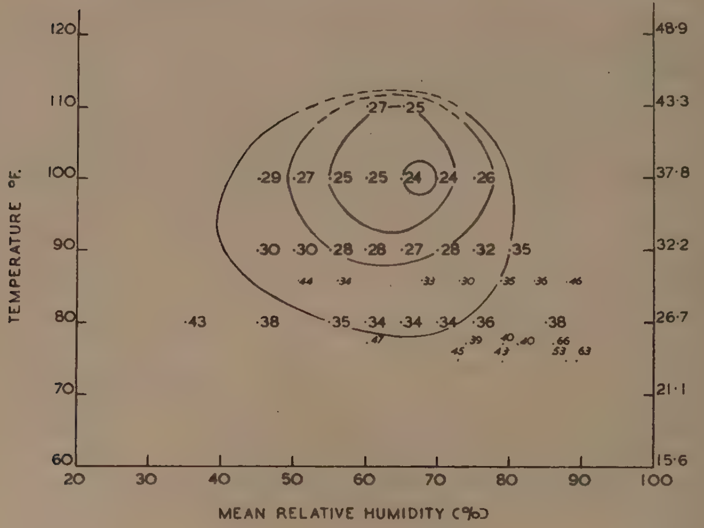

Fig. 8.—Lines showing the time required for development of *Schistocerca* hoppers at different constant relative humidities and temperatures. The results for alternating relative humidities and temperatures (calculated to give weighted mean humidities and temperatures) are shown in small type, but they are not taken into account when drawing the lines.

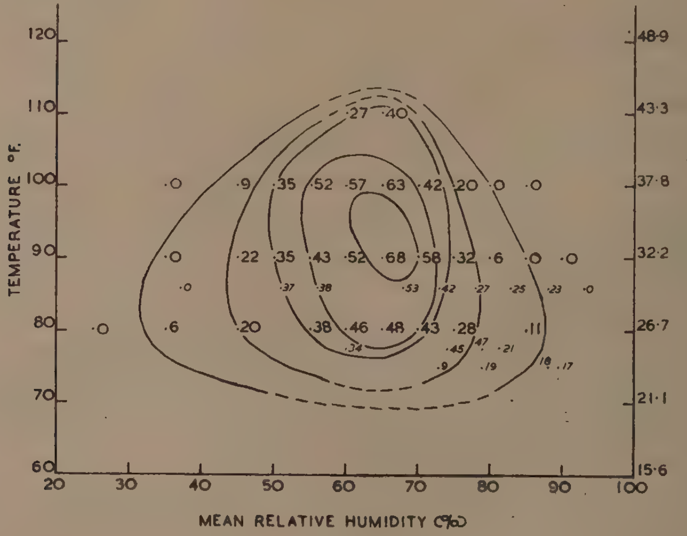

Fig. 9.—Lines showing the percentage of *Schistocerca* hoppers reaching the adult stage at different constant relative humidities and temperatures. The results for alternating relative humidities and temperatures (calculated to give weighted mean humidities and temperatures) are shown in small type, but they are not taken into account when drawing the lines.

produce interesting results. Experiments were arranged and carried out at temperatures which were changed at a given time each day. It was thus possible to record the time passed at each temperature as a fraction of the 24-hour day. The time passed at the high day temperature was 2/7 of the total, and at the low night temperature 5/7 of the total. The temperatures selected for these experiments were as follows :

(*a*) 90° F. (32·2° C.) during the day and the laboratory temperature of 68° F. (20° C.) during the night giving a weighted mean of 74·3° F. (23·5° C.).

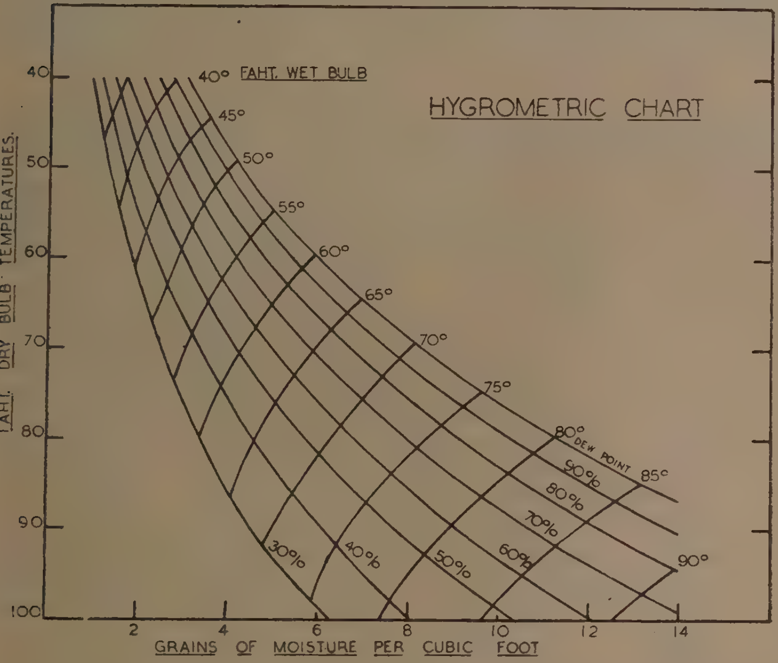

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Fig. 10.—Hygrometric chart, by means of which a change in relative humidity resulting from a change in temperature can be read.

(*b*) 100° F. (37·8° C.) during the day and the laboratory temperature of 68° F. (20° C.) during the night giving a weighted mean of 77·1° F. (25·1° C.).

(*c*) 100° F. (37·8° C.) during the day and 80° F. (26·7° C.) during the night giving a weighted mean ot 85·7° F. (30·9° C.).

The average laboratory temperature of 68° F. (20° C.) was arrived at after daily maximum and minimum records had been kept for over two years. During this period it was found that the variation in the summer and the winter night temperature of the laboratory was very small because the position of the laboratory prevented an excessive rise in summer, and the winter temperature was much higher than is normal for a laboratory owing to the large number of heated cages. Only on exceptional occasions did the temperature ever rise above 71° F. (21·7° C.) or fall below 65° F. (18·3° C.). Since the experiments extend over a period of at least one month any one extreme was generally counterbalanced by one in the opposite direction. At 100° F. and 80° F. both temperatures were controlled by a thermostat and therefore were more constant.

No attempt was made to produce an alternating humidity with a constant temperature, so both factors must be studied together. An alternating temperature automatically brings about a change in the relative humidity within a closed space. The variation may be calculated from physical tables (e.g. Hodgman, 1948), but for convenience they are shown in graphic form (fig. 10). These lines give the theoretical variation, which never occurred under experimental conditions because there was always a slight leakage of moisture at

TABLE 4.

Table showing the effect of alternating temperatures and humidities on the development of hoppers of *Locusta*. Approximately two-sevenths of time passed at the day temperature and humidity and five-sevenths at the night temperature and humidity.

Number of experiments.	Temp.	Variation in relative humidity.	Weighted mean relative humidity.	Number of hoppers at start of experiment.	Length of hopper life.			Number of hoppers to reach adult stage.	Percentage of hoppers to reach adult stage.
					Average.	Min.	Max.		
1	90° F. (32·2° C.) during day, 68° F. (20° C.) during night, i.e. weighted mean 74·3° F. (23·5° C.)	40 (65)* 60 (70)	54·3	62	53·6	49	59	14	22·7
1		50 (45) 75 (85)	67·9	99	41·2	38	45	57	57·6
1		55 (50) 80 (95)	72·9	71	39·6	36	45	52	73·2
1		60 (55) 85 (100)	77·9	36	40·6	35	45	25	69·4
2		65 (60) 90 (100)	82·9	72	44·4	35	50	29	40·3
2		70 (65) 95 (100)	87·9	108	47·4	43	55	29	26·9
1	100° F. (37·8° C.) during day, 68° F. (20° C.) during night, i.e. weighted mean 77·1° F. (25·1° C.).	60 (55) 90 (100)	81·4	33	38·9	36	43	18	57·6
1		65 (60) 95 (100)	86·4	33	42·0	40	44	12	36·3
1	100° F. (37·8° C.) during day, 80° F. (26·7° C.) during night, i.e. weighted mean 85·7° F. (30·9° C.).	25 (20) 35 (40)	32·1	46	All dead by 13th day.			0	0·0
1		30 (25) 40 (45)	37·2	41	48·0	42	54	2	4·9
1		35 (30) 45 (55)	42·1	25	36·8	32	42	5	20·0
3		40 (35) 55 (65)	50·7	124	31·0	26	40	36	29·0
2		45 (40) 65 (75)	59·3	56	29·0	23	33	35	62·5
2		50 (45) 75 (80)	67·9	75	27·7	22	34	57	76·0
7		60 (55) 85 (100)	77·9	299	27·9	22	32	225	75·2
2		65 (60) 90 (100)	82·9	68	32·7	28	36	41	60·3
3		70 (65) 95 (100)	87·9	285	35·1	25	42	59	20·7

* In this table and in tables 5, 9 and 10, the recorded day relative humidity, with the theoretical figure in brackets, is given above the line, the corresponding night relative humidities are given below the line.

the higher temperature and a certain amount of absorption by the sand at the lower temperature. In Tables 4 and 5 the figure giving the actual change in the relative humidity is followed by the theoretical figure in brackets. The day humidity is above the line and the night humidity below. It should be noted that at low humidities the difference between the theoretical relative humidity and the corresponding experimental figure for the upper limit of the humidity range was much greater than at high humidities. As the time passed at each temperature and humidity was known it was possible to calculate the weighted mean for both factors. The weighted mean humidity was calculated from the practical results and not from the theoretical figures. From these calculations (Tables 4 and 5) curves have been plotted (figs. 11 and 13) showing

TABLE 5.

Table showing the effect of alternating temperatures and humidities on the development of hoppers of *Schistocerca*. Approximately two-sevenths of time passed at the day temperature and humidity and five-sevenths at the night temperature and humidity.

Number of experiments.	Temp.	Variation in relative humidity.	Weighted mean relative humidity.	Number of hoppers at start of experiment.	Length of hopper life.			Number of hoppers to reach adult stage.	Percentage of hoppers to reach adult stage.
					Average.	Min.	Max.		
1	90°F. (32·2°C.) during day, 68°F. (20°C.) during night, i.e. weighted mean 74·3°F. (23·5°C.).	55 (50)* 80 (95)	72·9	57	45·1	43	46	9	17·6
3		60 (55) 85 (100)	77·9	175	43·0	33	49	41	23·4
1		70 (65) 95 (100)	87·9	96	52·7	45	65	17	17·7
2		75 (70) 95 (100)	89·3	137	63·3	56	69	23	16·8
2	100°F. (37·8°C.) during day, 68°F. (20°C.) during night, i.e. weighted mean 77·1°F. (25·1°C.).	35 (30) 70 (80)	60·0	167	46·6	40	56	56	33·5
2		45 (40) 85 (100)	73·6	53	39·1	32	45	24	45·3
1		50 (45) 90 (100)	78·6	51	39·6	38	44	24	47·1
2		60 (55) 90 (100)	81·4	48	44·9	40	55	10	20·8
1		65 (60) 95 (100)	86·4	59	52·9	48	58	7	10·9
1	100°F. (37·8°C.) during day, 80°F. (26·7°C.) during night, i.e. weighted mean 85·7°F. (30·9°C.).	30 (25) 40 (45)	37·1	39	All dead by end of 6th day				0·0
1		40 (35) 55 (65)	50·7	46	43·9	37	46	17	37·0
2		45 (40) 65 (75)	59·3	138	34·2	29	41	53	38·3
2		50 (45) 75 (80)	67·9	57	32·6	25	38	30	52·6
2		55 (50) 80 (90)	72·9	130	29·6	25	35	54	41·5
4		60 (55) 85 (100)	77·9	189	35·4	28	42	50	26·5
3		65 (60) 90 (100)	82·9	288	36·9	29	49	72	25·0
1		70 (65) 95 (100)	87·9	47	45·5	37	55	11	23·4
1		75 (70) 100 (100)	92·9	30	All dead by 21st day			0	0

* See note, Table 4.

the effect of different weighted mean relative humidities at the different weighted mean temperatures on the rate of development. Also it was possible to obtain the optimal rate of development for the weighted mean temperatures and to apply the results to the curves showing the effect of temperature on the development of hoppers of both species. Likewise the effect of alternating conditions on the percentage of hoppers reaching the adult stage could be studied (figs. 12 and 14).

(a) *Locusta.*

Table 4 shows that at a temperature alternating between 90° F. and 68° F. (weighted mean 74·3° F.) the minimum time required for hopper development is 39·6 days at a relative humidity alternating between 55 (50)% and 80(95)% (weighted mean relative humidity of 72·8%). Thus the best experimental result (Table 6) is very close to the optimal point (39·5 days) at 75% relative humidity on the curve (fig. 11) for this temperature. Both these figures are slightly higher than the 38·3 days obtained from the equation $(x - 53)\ (y - 9) = 635$, and shown on curve L of fig. 3.

TABLE 6.

Table showing a comparison between the theoretical results from the equations, the best experimental results, and the optimal points obtained from the curves (figs. 11 and 13) for the time required for the development of *Locusta* and *Schistocerca* hoppers.

Locusta.

Weighted mean temperature ° (F.).	Theoretical time from $(x-53)\ (y-9) = 635$.	Best experimental result.	Optimal point from curves (fig. 11).
74·3	38·3 days	3·6 days	39·5 days
77·1	35·2 „	— „	— „
85·7	28·4 „	27·7 „	27·5 „

Schistocerca.

Weighted mean temperature (° F.).	Theoretical time from $(x-63)\ (y-16) = 300$.	Best experimental result.	Optimal point from curves (fig. 12).
74·3	41·6 days	43·0 days	42·6 days
77·1	37·1 „	39·1 „	38·8 „
85·7	29·2 „	29·6 „	29·4 „

At temperatures alternating between 100° F. and 68° F. (weighted mean 77·1° F.) the number of experiments is too small to enable any conclusions to be drawn. Also the humidities employed could not be considered as favourable. However, the trend of the curve suggests an optimum at a relative humidity between 70% and 75%. This would correspond with humidity alternating between 45(40)% and 85(100)%, and the time required for development might be about 35 days. The equation gives the minimum time for development as 35·2 days.

The next combination of temperatures, 100° F. and 80° F. (weighted mean 85·7° F.) shows that the best experimental result of 27·7 days at a weighted mean humidity of 67·9% (i.e. alternating between 50(45)% and 75(80)%) is very close to the best point (27·5 days at approximately 73%) on the curve (fig. 11). Both these times are slightly shorter than the 28·4 days obtained from the equation and curve L of fig. 3.

When examining the curves in fig. 11, showing the effect of alternating humidities at different alternating temperatures, it should be noted that they are not as markedly flattened at the higher limits as in the case of curves showing the effect of constant humidities, and that they show no flattening at all at the lower humidities. It should also be noted that under alternating conditions the minimum time required for development, at all temperatures, occurs at relative humidities which give a calculated weighted mean between 70% and 75% (fig. 11) as compared with relative humidity between 65% and 70% (fig. 1) under constant conditions.

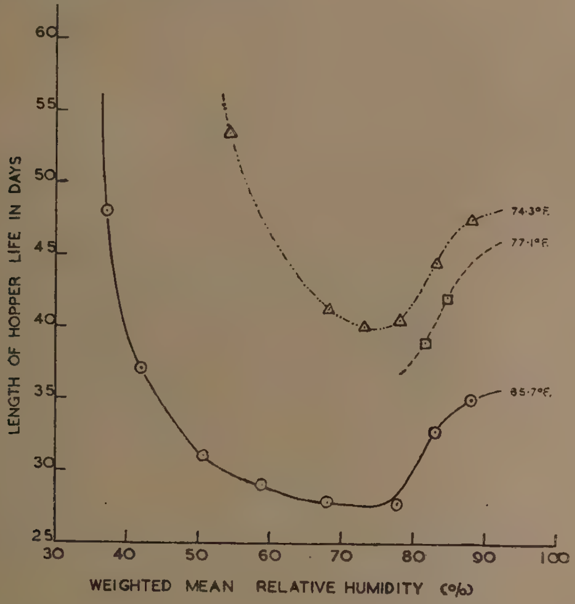

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Fig. 11.—The effect of alternating relative humidities at different alternating temperatures (calculated to give weighted mean humidities and temperatures) on the time required for development of *Locusta* hoppers.

The combined effect of alternating humidities and temperatures (after calculation to give a weighted mean) on the time required for development of hoppers is shown in small type in fig. 4. Owing to the fact that nothing is known about alternating temperatures above 100° F. to 80° F. (weighted mean 85·7° F.) no attempt has been made to join these points, or to include them in the circles formed by joining points obtained under constant conditions. It can, however, be seen that the centre of optimal development has moved to the right, i.e. to a slightly higher weighted mean relative humidity than in the case of constant conditions. How high it would be possible to increase the upper temperature under alternating conditions is not known, but judging from the results obtained at constant temperatures, and from Hussein's work, (1937) it would seem that 110° F. would be the maximum. Owing to certain technical difficulties it was not found possible to carry out experiments with 110° F. as the upper limit.

Turning to the effect of alternating conditions of humidity and temperature on the percentage of *Locusta* hoppers reaching the adult stage, it can be seen from Table 4 and fig. 12 that the reaction is very similar to that found under constant conditions. That is, the relative humidity (weighted mean 70% to 75%) which gives the fastest rate of hopper development at the various temperatures also gives the highest percentage of hoppers reaching the adult stage. The highest percentage of hoppers at the weighted mean temperature of 85·7° F. is approximately mid-way between the percentages found under constant conditions at 90° F. and at 80° F. At a combination of temperatures giving a weighted mean of 74·3° F., the curve showing the percentage of hoppers reaching the adult stage, lies within the curve for 85·7° F., except when the weighted mean relative humidity reaches 85% and above.

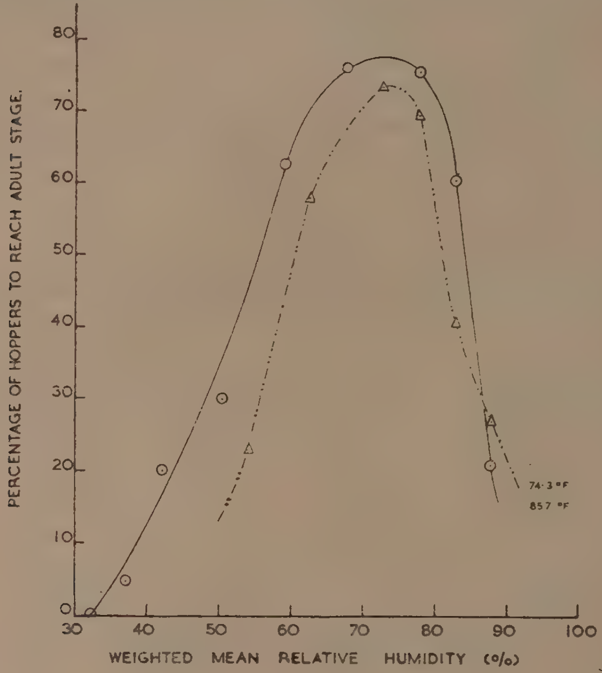

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Fig. 12.—The effect of alternating relative humidities at different alternating temperatures (calculated to give weighted mean humidities and temperatures) on the percentage of *Locusta* hoppers reaching the adult stage.

The flatness of the curves for these temperatures, around the optimum, should be compared with the more pronounced peaks found when the temperatures are constant.

These temperature curves giving the percentage of hoppers which reach the adult stage at different weighted mean relative humidities, like the curves for time required for development, show that the optimal percentage point (fig. 5) has moved towards the right, as compared with results under constant conditions. Also judging by the results at the lowest temperature it would seem that the centre of highest percentage reaching the adult stage has moved down slightly. The higher percentage of hoppers reaching the adult stage at the weighted mean temperature of 74·3° F., as compared with the percentage at a constant temperature of 75° F., may be due to a widening of the field of development resulting from a stimulus brought about by alternating conditions, which only becomes apparent when constant conditions reach less favourable temperatures.

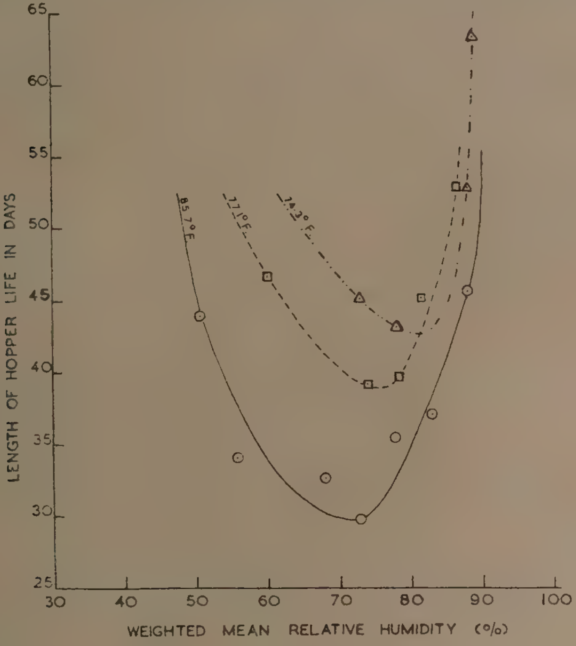

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Fig. 13.—The effect of alternating relative humidities at different alternating temperatures (calculated to give weighted mean humidities and temperatures) on the time required for development of *Schistocerca* hoppers.

(b) *Schistocerca.*

Except for a slight difference in the weighted mean relative humidity, for optimal development, the results (Table 5 and fig. 13) for this species, under alternating conditions, are very similar to those obtained for *Locusta*. At 90° F. and 68° F. (weighted mean 74·3° F.) the best experimental result (43·0 days) occurs at a relative humidity of 60(55)% during the day and 85 (100)% during the night (weighted mean 77·8%). This result is very close to the best point (42·6 days) on the curve at this temperature, and both are a little higher than the 41·6 days (Table 6) obtained from the equation $(x - 63)(y - 16) = 300$ and shown in Curve s of fig. 3. At a temperature alternating between 100° F. and 68° F. (weighted mean 77·1° F.) the best experimental result (39·1 days) occurs at a relative humidity alternating from 45(40)% to 85(100)% (weighted mean 73·8%), which is very close to the optimum (38·8 days) obtained from the curve (fig. 13), but both are again higher than the theoretical result of 37·1 days given by the equation.

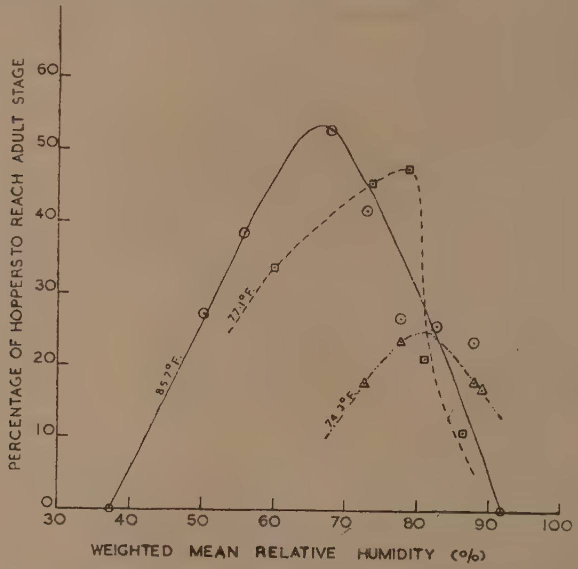

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Fig. 14.—The effect of alternating relative humidities at different alternating temperatures (calculated to give weighted mean relative humidities and temperatures) on the percentage of *Schistocerca* hoppers reaching the adult stage.

At the next temperatures, 100° F. and 80° F. (weighted mean 85·7° F.), the shortest time required for development is 29·6 days at 55(50)% and 80(90)% (weighted mean 72·8%) relative humidity. This result is very close to the optimum (29·2 days) obtained from the curve, and also to the time (29·2 days) from the equation. In the case of this species it should be noted (fig. 13) that the relative humidity for optimal development decreases as the temperature increases, in much the same manner and amount as in the case of *Locusta*.

The combined effect of alternating temperatures and humidities on the time required for hopper development is shown, in small type, in fig. 8. No attempt has been made to join these points, but it can be seen that optimal development occurs at a higher mean relative humidity than under constant conditions. Also, as in the case of *Locusta*, there does not appear to be any difference in the effect of a weighted mean temperature and a constant temperature.

Under alternating conditions of humidity and temperature the percentage of *Schistocerca* hoppers reaching the adult stage (fig. 14) shows the same relationship to the time required for development as did *Locusta* hoppers. Thus, at any given weighted mean temperature the highest percentage of hoppers reaching the adult stage occurs at approximately the same weighted mean relative humidity as the fastest rate of development. It should, however, be noted (figs. 13 and 14) that at the higher weighted mean relative humidities there is considerable crossing of the weighted mean temperature curves. For example, no curve in fig. 14 lies completely within another (*cf.* fig. 12, where the curve for 74·3° F. almost lies within the one for 85·7° F.), but shows a movement towards a higher weighted mean humidity as the weighted mean temperature is reduced.

The combined effect of weighted mean relative humidities and temperatures is shown (in small type) in figure 9, where it can be seen that the optimal percentage occurs at a slightly higher relative humidity than when conditions are constant.

IV. THE EFFECT OF CONSTANT CONDITIONS OF HUMIDITY AND TEMPERATURE ON ADULTS.

All these experiments were carried out at approximately the same relative humidities and temperatures as those at which the hoppers were reared. It is, therefore, necessary to bear in mind that the range of these experiments is restricted to the range of relative humidity and temperature at which it is possible for hoppers to develop and reach the adult stage. As Hamilton (1936) has shown that *Schistocerca* die out if kept at a constant temperature of 100° F. for a number of generations, and as will be seen later (p. 43), it has been impossible to obtain a second generation of this species at a constant temperature of 110° F., all experimental locusts were the progeny of stock kept at a relative humidity and temperature which maintained vitality.

(a) *Locusta.*

Table 7 and fig. 15 show that for all temperatures the length of adult life is very short around a relative humidity of approximately 70%, where sexual maturation occurs rapidly (*cf.* fig. 16), and that it gradually increases as the time required to reach sexual maturity increases, until just before the lower and upper limits of relative humidity suitable for sexual development are reached. Below and above these limits for sexual development the length of life begins to decrease. Thus within a certain range of relative humidity the length of life of the adult depends upon the rate of sexual maturation, but outside this range it depends directly upon the relative humidity.

The bimodal nature of the curves for length of adult life (fig. 15) is very important, and requires careful interpretation of all results, because it is possible to have the same result (i.e. length of life) at four different humidities on the

TABLE 7.

Table showing the effect of humidity on adults of *Locusta* at different temperatures.

Number of experiments.	Temp.	Relative humidity.	Number of adults in experiment.		1st pair *in cop.*, average days.	1st egg pod, average days.	Number of egg pods.	Average number of egg pods per ♀.	Length of adult life.		
			♂♂.	♀♀.					Average in days.	Min. in days.	Max. in days.
1	75° F. (23·9° C.)	70	4	7	—	33·0	26	3·7	84·6	43	115
1		75	4	6	—	34·0	17	2·8	60·1	11	95
1		85	3	4	—	35·0	7	1·8	66·3	33	102
1	80° F. (26·7° C.)	35	13	18	—		0	0·0	25·5	1	64
1		50	14	16	—	46·0	8	0·5	67·2	15	102
1		65	10	12	—	32·0	13	1·1	63·4	29	86
2		70	21	10	—	24·5	23	2·3	44·5	9	88
2		75	12	12	25·0	32·5	30	2·5	53·4	4	111
2		80	21	25	—	33·0	52	2·1	78·0	10	179
1		85	11	12	—	42·0	3	0·4	54·5	13	92
1	90° F. (32·2° C.)	35	5	6	—	—	0	0	35·6	18	58
1		40	6	7	—	67·0	6	0·9	69·0	23	112
2		50	11	18	—	39·0	29	1·6	71·1	23	123
2		55	16	12	28·0	33·5	23	1·9	54·8	22	109
3		60	34	28	24·0	26·7	61	2·2	49·0	5	97
3		65	16	16	13·0	20·3	45	2·8	45·0	13	87
3		70	12	15	—	17·7	70	4·7	43·8	6	89
6		75	42	41	22·0	25·3	164	4·0	56·1	11	116
3		80	27	26	—	33·7	56	2·2	71·5	5	128
2		85	12	16	19·0	41·0	20	1·3	61·5	22	121
1	100° F. (37 8° C.)	40	6	6	15·0	43·0	2	0·3	39·3	5	65
2		45	7	6	16·0	31·0	7	1·2	38·5	16	88
2		55	25	20	16·0	21·0	28	1·4	46·6	2	78
2		60	14	11	17·0	20·5	23	2·1	53·8	19	95
2		65	9	17	—	16·5	45	2·6	53·7	7	113
2		70	5	7	9·5	12·0	21	3·0	34·3	15	62
4		75	19	21	9·3	13·8	49	2·3	34·9	4	81
2		80	13	9	13·0	22·0	11	1·2	41·9	6	93
1		85	8	10	19·0		0	0·0	35·6	15	46
2	110° F. (43·3° C.)	55	6	6	9	—	0	0·0	22·5	8	31
1		60	6	3	10	38·0	1	0·3	45·0	23	65
3		65	23	18	—	17·3	9	0·5	31·5	2	66
1		70	2	4	—	15·0	9	2·3	20·7	7	37
1		75	4	6	—	17·0	20	3·3	26·2	15	36
2		80	15	6	—	18·0	4	0·7	25·4	12	34

same temperature curve. The curves for 80°, 90°, 100° and 110° F. all conform to the same plan, with a central portion at about 70% relative humidity where the length of life is short (these may be regarded as optimal points), due to a rapid rate of sexual maturation (fig. 16) and a high average number of egg pods per female (fig. 18). As the relative humidity is increased above the optimum the length of adult life and the time required to reach sexual maturity increase, but the number of egg pods per female decreases, until a relative humidity of approximately 80% for temperatures of 80°, 90° and 100° F., and a relative humidity of 77% for temperature of 110° F., is reached, when the rate of sexual maturation is still more retarded and the number of egg pods very small. Above these relative humidities the length of adult life begins to decrease, and the number of egg pods is few or none at all, as death may occur before sexual maturation takes place. Below the optimum the curves show that there is also a gradual increase in the length of adult life until a point is reached where a low humidity, and not sexual maturity, brings about a reduction in the length of adult life. This turning-point is not so well defined at the low humidities as it is at the high humidities above the optimum. All that can be said is that it occurs at relative humidities between 45% and 60% depending on the temperature.

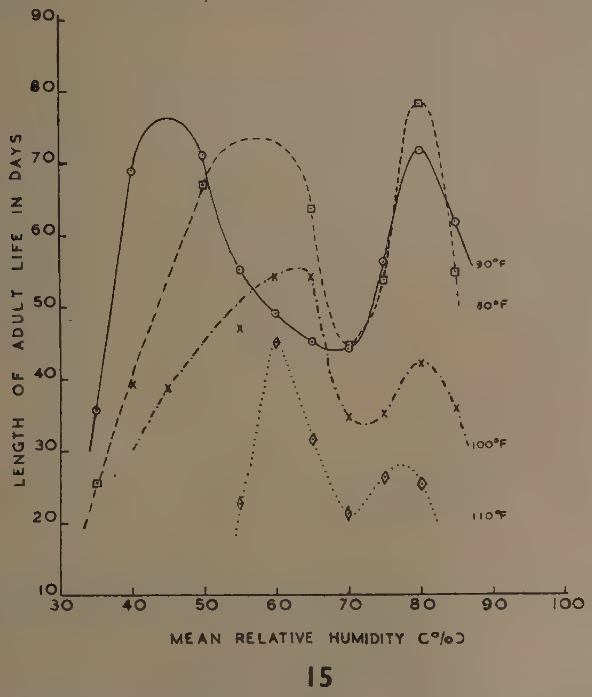

FIG. 15.—The effect of relative humidity at different constant temperatures on the length of adult life of *Locusta.*

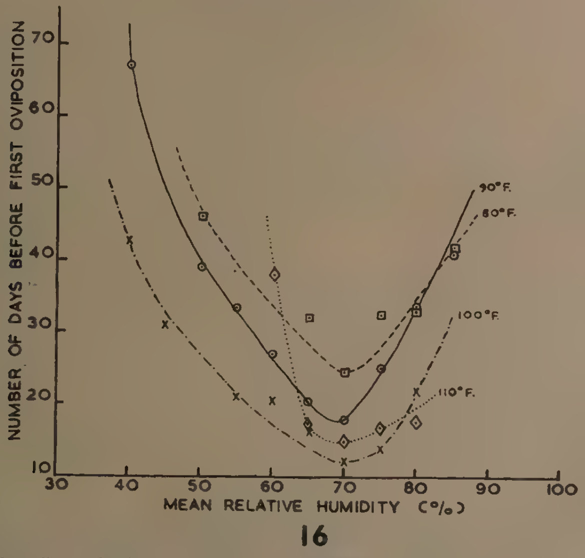

FIG. 16.—The effect of relative humidity at different constant temperatures on the time required for *Locusta* to reach sexual maturity.

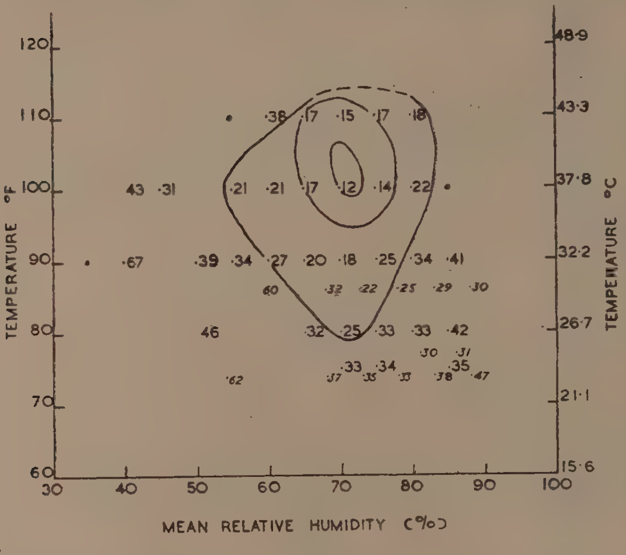

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Fig. 17.—Lines showing the time required for *Locusta* to reach sexual maturity at different constant relative humidities and temperatures. The results for alternating relative humidities and temperatures (calculated to give weighted mean relative humidities and temperatures) are shown in small type, but are not taken into account when drawing the lines.

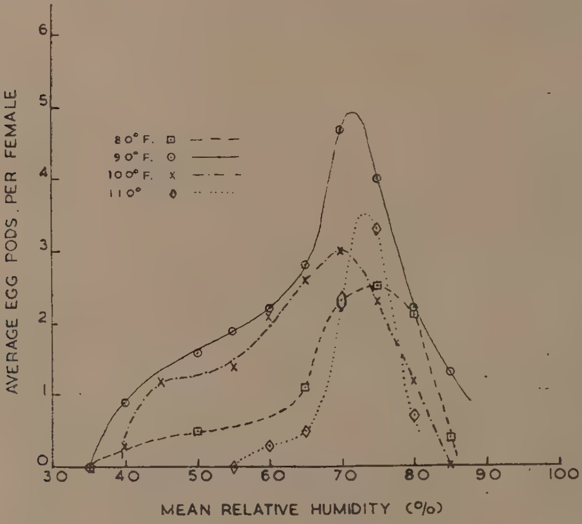

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Fig. 18.—The effect of relative humidity at different constant temperatures on the average number of egg pods per female of *Locusta*.

In order to get a complete picture of the effect of temperature on adults it is necessary to study the effect of both constant humidities and temperatures (Table 7, and figs. 15, 16, 17, 18 and 19). In all these figures the majority of the curves show an optimum at approximately 70% relative humidity, but a few either decrease to almost 65%, or increase to almost 75% for the optimum. While it is, therefore, possible to regard a relative humidity of approximately 70% as the optimal relative humidity, these figures show that it is not possible to be so definite about an optimal temperature. For example, the length of adult life, following sexual maturation and egg depositing, is shortest (this may be taken as optimum) at 110° F. (fig. 15), yet the minimum time required for sexual maturation occurs at 100° F. (fig. 16). If figure 17 is examined it will be seen that there is a hypothetical optimum, at a temperature slightly above 100° F., where there appears to be a central point surrounded by lines joining points giving times required for sexual maturation. This is perhaps the true optimum for sexual maturation. The maximum number of egg pods (4·8) per female (fig. 18) occurs at yet another temperature, i.e. 90° F., but still at a relative humidity very close to 70%. From these variations it would seem that no one temperature can be regarded as the best for all purposes.

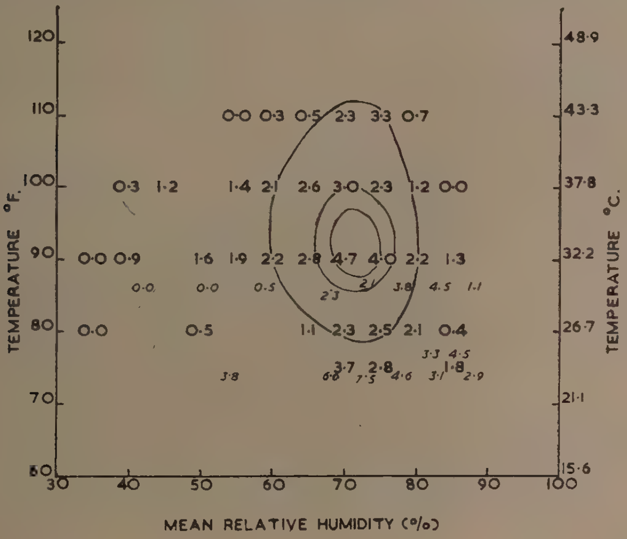

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FIG. 19.—Lines showing the average number of egg pods per female of *Locusta* at different constant relative humidities and temperatures. The results for alternating relative humidities and temperatures (calculated to give weighted mean relative humidities and temperatures) are shown in small type, but are not taken into account when drawing the lines.

In general the curves in all these figures show that humidity has a more marked effect at 110° F. than at the low temperatures. This seems to hold in the case of the bimodal curves as well as for the simple curves. Also, when comparing these curves, it should be noted that the curves showing the average number of egg pods per female are of a different nature from any of the others. They show a rapid drop at relative humidities immediately below their optima, and then at a relative humidity between 60% and 65% they flatten considerably. This change in the curves occurs at approximately the same relative humidity (*cf.* fig. 15) as the decrease in length of adult life due to unfavourable conditions, and not to the completion of ovipositing. Therefore a slight change in one set of humidities which in itself seems unimportant does have a meaning when compared with some others.

(b) *Schistocerca.*

Owing to the difficulty of rearing this species at 110° F. it is only possible to give comprehensive results of the effect of humidity at 80°, 90° and 100° F. Another outstanding feature is the low relative humidity at which it is possible to keep the adults without causing a shortening of the length of adult life as was the case with *Locusta*. From Table 8 and fig. 20 it can be seen that there

TABLE 8.

Table showing the effect of humidity on adults of *Schistocerca* at different temperatures.

Number of experiments.	Temp.	Relative humidity.	Number of adults in experiment.		1st pair *in cop.*, average days.	1st egg pod, average days.	Number of egg pods.	Average number of egg pods per ♀.	Length of adult life.		
			♂♂.	♀♀.					Average in days.	Min. in days.	Max. in days.
1	80° F. (26·7° C.)	60	5	6	—	29·0	11	1·8	97·2	16	218
1		65	8	4	—	28·0	7	1·9	87·0	27	161
2		75	16	17	—	51·0	26	1·5	96·8	8	198
3		80	17	20	—	53·0	8	0·4	69·4	1	106
1		85	8	7	—	—	0	0·0	28·3	1	92
2	90° F. (32·2° C.)	40	19	14	— 83	— 132·0	0 6	0·4	124·2	1	261
2		50	12	10	.	47·0	11	1·1	76·3	10	181
2		60	13	18	.	33·0	13	2·5	66·1	25	99
2		65	15	14	.	27·5	64	4·6	53·3	19	107
5		70	18	28	19	26·2	77	2·8	41·2	4	129
2		75	10	11	26	31·0	19	1·7	56·2	3	92
3		80	8	17	—	42·7	12	0·7	60·0	1	139
2	100° F. (37·8° C.)	45	8	12	47	55·0	9	1·3	72·0	57	97
1		50	4	8	.	30·0	17	2·1	48·6	42	59
1		55	5	5	21	22·0	15	3·0	46·0	42	64
1		60	7	6	17	20·0	25	4·2	40·2	35	75
2		65	13	18	.	17·0	52	2·9	34·8	13	112
2		70	13	14	13	19·5	16	1·2	23·3	4	64
2		75	12	9	25	31·5	9	1·0	25·5	2	69
3		80	10	12	50 —	55·0 —	7 0	0·6	52·4	2	130
1	110° F. (43·3° C.)	60	5	4	—	—	0	0·0	63·2	25	114
1		65	2	3	—	50·0	1	0·3	39·8	7	59

is a definite optimum which is at a relative humidity of approximately 70% for all three temperatures. On examining these curves it can be seen that as the higher relative humidities are reached the increase in length of adult life is closely linked with the increase in the time required to reach sexual maturity (*cf.* fig. 21), until a point is reached where sexual maturation no longer occurs. This change takes place at relative humidities of 76%, 78% and 80% respectively for the three temperatures 80°, 90° and 100° F., whereas in the case of *Locusta* it occurred at a relative humidity of 80% for all temperatures. Above this the length of adult life decreases as the relative humidity increases and the adults die without becoming sexually mature. Except for this very slight difference at the upper limits of relative humidity the results above the optimal relative humidity for *Locusta* and *Schistocerca* conform to a general plan. At relative humidities below the optimum the curves show a marked difference for the two species; the length of adult life of *Schistocerca* seems to go on increasing (fig. 20) as the relative humidity decreases, and does not reach a point (within the range of these experiments) where the length of adult life

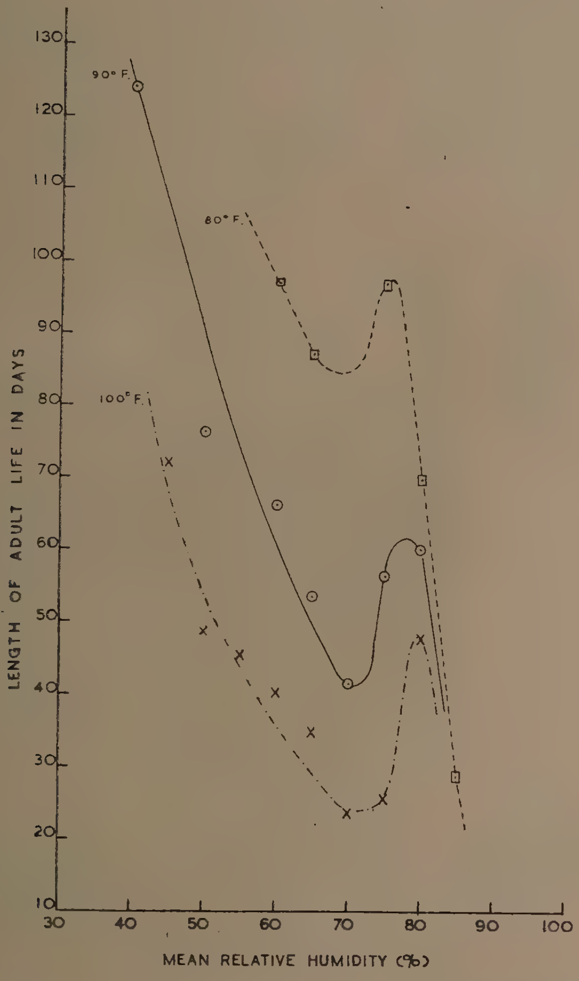

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Fig. 20.—The effect of relative humidity at different constant temperatures on the length of adult life of *Schistocerca*.

decreases, as a result of unfavourable low humidities causing death before sexual maturity is reached, as was the case with *Locusta* adults (*cf.* fig. 15). The curves in fig. 20 show that for all three temperatures the optimum occurs at approximately 70% relative humidity, but when the curves in figs. 21 and 23 are examined a considerable variation can be seen at the different temperatures. For example, fig. 21 shows that the optimal humidity for sexual

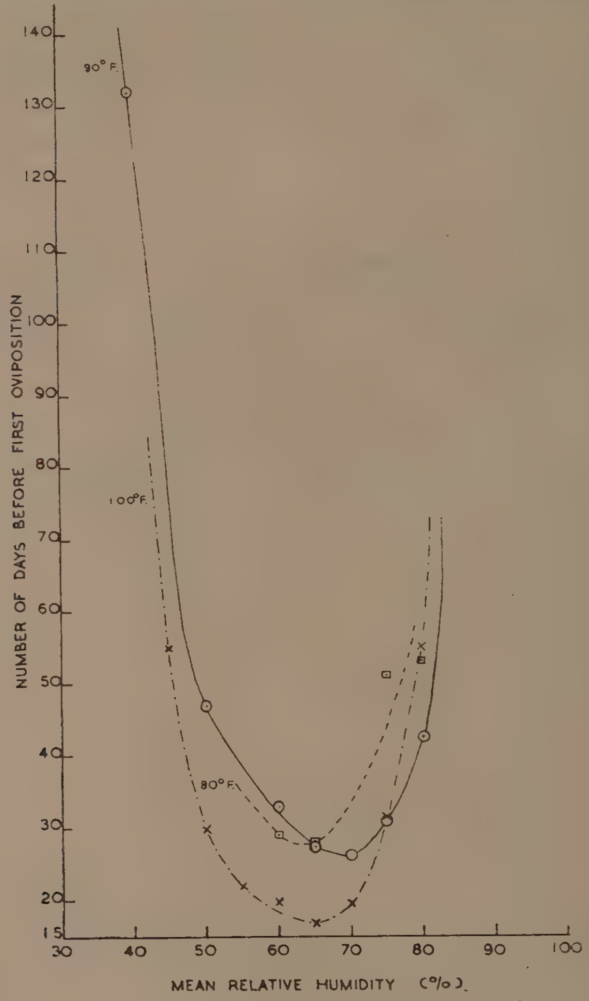

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FIG. 21.—The effect of relative humidity at different constant temperatures on the time required for *Schistocerca* to reach sexual maturity.

maturation at 90° F. is 70%, but at 80° F. and 100° F. the optimum occurs at approximately 65% relative humidity. Indeed the whole curve at 90° F. is more towards the higher relative humidities than the curves at 80° F. or 100° F. In fig. 23 there is a similar variation as the curve at 90° F. is at higher relative humidities than the curves at 80° F. and 100° F. Also in this figure the optima all occur at lower humidities than was the case for curves showing the times required to reach sexual maturity, etc. It would therefore seem from this figure (showing the average egg pods per *Schistocerca* female) and from fig. 18 (showing the average egg pods per *Locusta* female) that the maximum number of egg pods for either species does not necessarily occur at the relative humidity which gives the fastest rate of sexual maturation at a given temperature.

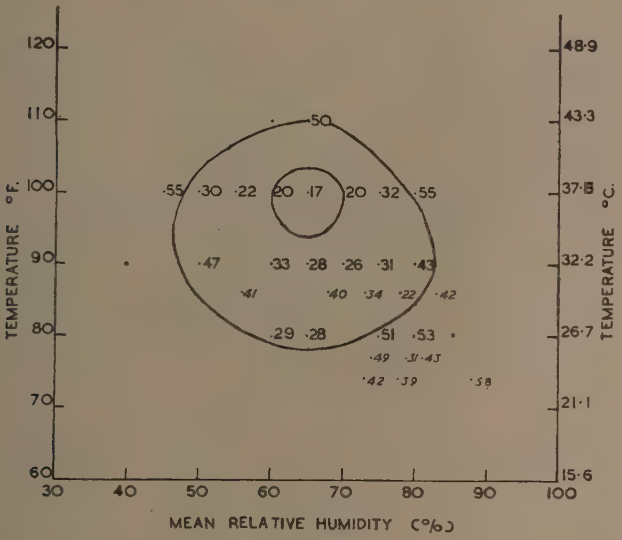

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Fig. 22.—Lines showing the time required for *Schistocerca* to reach sexual maturity at different constant relative humidities and temperatures. The results for alternating relative humidities and temperatures (calculated to give weighted mean relative humidities and temperatures) are shown in small type, but are not taken into account in drawing the lines.

According to the lines showing times required for sexual maturation at different constant relative humidities and different constant temperatures in fig. 22 the optimal temperature is just below 100° F. for *Schistocerca*, whereas in the case of *Locusta* it is just above 100° F. (fig. 17). Although the time required for sexual maturation gives some indication of the optimal conditions, it is not the only one, as the number of egg pods per female must be considered and in both species 90° F. gives the best results, but according to the lines showing average number of egg pods per female, 94° F. (fig. 19) is the optimum for *Locusta* and 95° F. (fig. 24) for *Schistocerca*. That 110° F. is not a suitable tem-

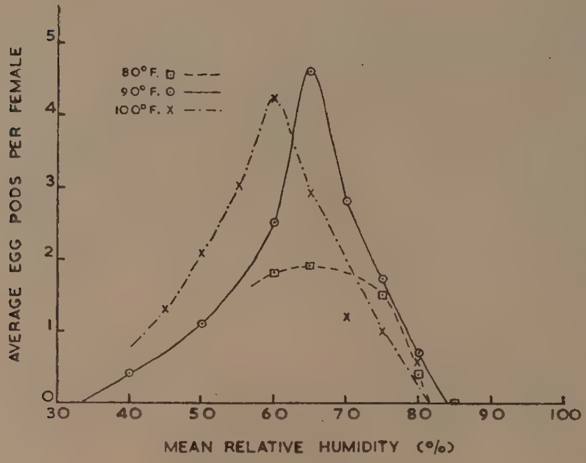

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Fig. 23.—The effect of relative humidity at different constant temperatures on the average number of egg pods per female of *Schistocerca*.

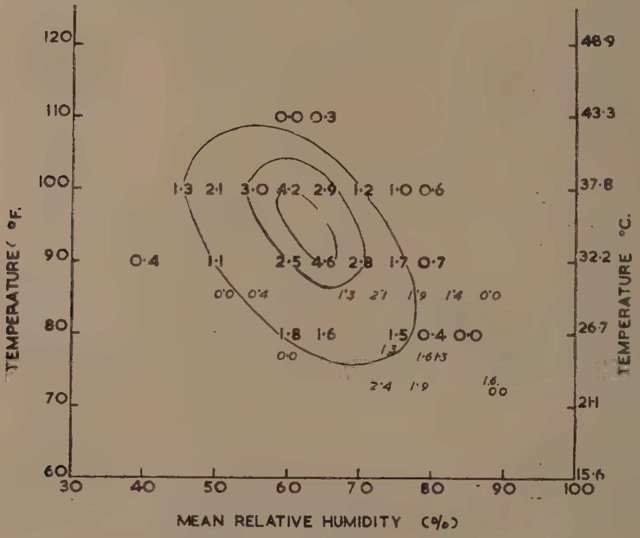

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Fig. 24.—Lines showing the average number of egg pods per female of *Schistocerca* at different constant relative humidities and temperatures. The results for alternating relative humidities and temperatures (calculated to give weighted mean relative humidities and temperatures) are shown in small type, but are not taken into account when drawing the lines.

perature for *Schistocerca* adults is evident by the fact that it required 50 days before the first and only egg pod was deposited at a relative humidity of 65%. This is much longer than the time required at 100° F. At a relative humidity of 60% the adults all died without attaining sexual maturity. As both these humidities should be suitable it can only be concluded that this temperature is unsuitable. These results are in keeping with those for hopper development (p. 12), as hoppers required longer to reach the adult stage at 110° F. than at 100° F.

Fig. 24 shows that the optimum temperature for egg pods per female is definitely below 100° F.

TABLE 9.

Table showing the effect of alternating temperatures and humidities on sexual maturation, fecundity and length of adult life of *Locusta*. Approximately two-sevenths of time passed at the day temperature and humidity and five-sevenths at the night temperature and humidity.

Number of experiments.	Temperature.	Variation in relative humidity.	Weighted mean relative humidity.	Number of adults in experiment		1st pair *in cop.*, days.	1st egg pod, days.	Number of egg pods	Average number of egg pods per ♀.	Length of adult life.		
				♂♂.	♀♀.					Average in days.	Min. in days.	Max. in days.
1	90° F. (32·2° C.) during day, 68° F. (20° C.) during night, i.e. weighted mean 74·3° F. (23·5° C.)	40 (35)* 60 (70)	54·3	4	6	—	62·0	23	3·8	74·6	18	121
2		50 (45) 75 (85)	67·9	25	11	30	37·0	73	6·6	94·1	15	212
1		55 (50) 80 (90)	72·9	4	4	30	35·0	30	7·5	111·9	83	130
2		60 (55) 85 (100)	77·9	13	14	18	33·0	65	4·6	98·0	18	160
1		65 (60) 90 (100)	82·9	7	11	—	38·0	34	3·1	115·4	42	168
1		70 (65) 95 (100)	87·9	5	9	—	47·0	26	2·9	76·1	25	83
1	100° F. (37·8° C.) during day, 68° F. (20° C.) during night, i.e. weighted mean 77·1° F. (25·1° C.).	60 (55) 95 (100)	81·4	5	4	14	30·0	13	3·3	65·1	28	134
1		65 (60) 95 (100)	86·4	6	4	—	31·0	19	4·8	76·5	32	102
1	100° F. (37·8° C.) during day, 80° F. (26·7° C.) during night, i.e. weighted mean 85·7° F. (30·9° C.).	35 (30) 45 (55)	42·1	2	4	—	—	0	0·0	16·3	5	57
1		40 (35) 55 (65)	50·7	3	2	—	—	0	0·0	25·2	21	29
2		45 (40) 65 (75)	59·3	17	19	—	60·0	10	0·5	53·1	8	102
2		50 (45) 70 (80)	67·9	12	15	—	31·5	27	2·3	67·1	10	105
1		55 (50) 80 (90)	72·9	8	8	20	22·0	17	2·1	75·4	9	186
3		60 (55) 85 (100)	77·9	25	22	16	25·0	85	3·8	66·3	7	110
4		65 (60) 90 (100)	82·9	21	22	—	28·8	100	4·5	79·9	31	103
3		70 (65) 95 (100)	87·9	49	44	29	30·0	49	1·1	67·3	20	206

* See note, Table 4.

V. THE EFFECT OF ALTERNATING CONDITIONS OF HUMIDITY AND TEMPERATURE ON ADULTS.

These experiments on adults were also carried out under similar conditions of humidity and temperature as those at which the hoppers were reared (see above, p. 13). This, as in the case of constant conditions, restricts the range of temperatures used. The temperatures were changed at fixed times during the 24 hours, so it was possible to calculate the weighted mean humidity and temperature (Tables 9 and 10), and then plot against the calculated weighted mean relative humidity, the length of adult life in days (figs. 25 and 28), the time required to reach sexual maturity (figs. 26 and 29), and the average egg pods per female (figs. 27 and 30). In the case of *Locusta* adults compre-

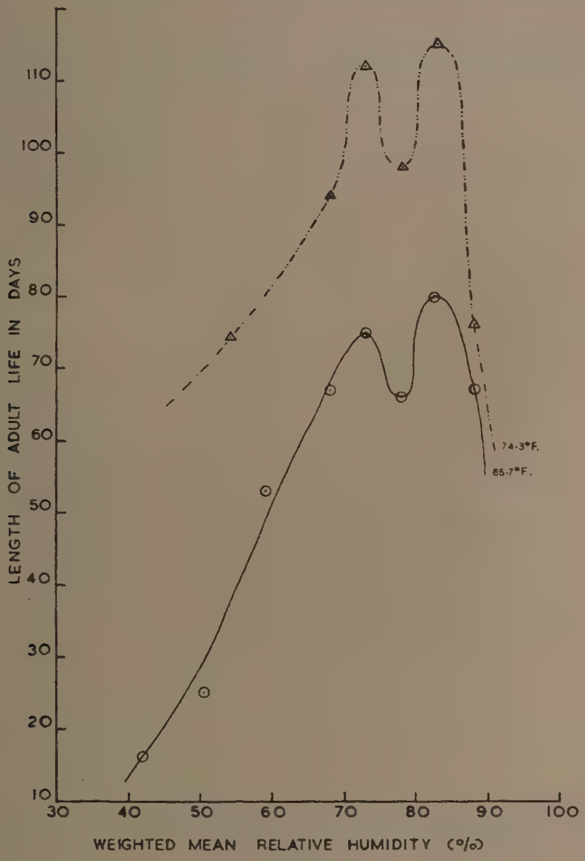
TABLE 10.

Table showing the effect of alternating temperatures and humidities on sexual maturation, fecundity and length of adult life of *Schistocerca*. Approximately two-sevenths of time passed at the day temperature and humidity and five-sevenths at the night temperature and humidity.

Number of experiments.	Temperature.	Variation in relative humidity.	Weighted mean relative humidity.	Number of adults in experiment		1st pair *in cop.*, days.	1st egg pod, days.	Number of egg pods.	Average number of egg pods per ♀.	Length of adult life.		
				♂♂.	♀♀.					Average in days.	Min. in days.	Max. in days.
2	90°F. (32·2°C.) during day, 68°F. (20°C.) during night, i.e. weighted mean 74·3°F. (23·5°C.).	55 (50)* / 80 (95)	72·8	12	12	30	42·0	29	2·4	113·5	24	208
2		60 (55) / 85 (100)	77·8	8	7	30	38·5	13	1·9	72·0	7	150
2		70 (65) / 95 (100)	87·9	16	9	—	57·5	14	1·6	86·8	22	171
1		75 (70) / 95 (100)	89·3	6	5	—	—	0	0·0	66·8	4	104
1	100°F. (37·8°C.) during day, 68°F. (20°C.) during night, i.e. weighted mean 77·1°F. (25·1°C.).	35 (30) / 70 (80)	60·0	7	11	—	—	0	0·0	52·9	26	130
1		45 (40) / 85 (100)	73·8	12	6	—	49·0	2	0·3	89·1	35	190
2		50 (45) / 90 (100)	78·6	9	10	24	31·0	16	1·6	58·9	4	94
1		60 (55) / 95 (100)	81·4	2	3	—	43·0	4	1·3	62·3	32	85
2	100°F. (37·8°C.) during day, 80°F. (26·7°C.) during night, i.e. weighted mean 85·7°F. (30·9°C.).	40 (35) / 55 (65)	50·6	8	8	—	—	0	0·0	27·0	7	67
1		45 (40) / 60 (75)	55·8	8	9	35	41·0	4	0·4	73·9	44	165
2		50 (45) / 75 (80)	67·9	13	7	39	40·0	9	1·3	66·7	23	105
3		55 (50) / 80 (90)	72·8	24	15	—	33·7	31	2·1	60·2	6	174
2		60 (55) / 85 (100)	77·8	24	19	—	21·5	37	1·9	57·0	14	95
2		65 (60) / 90 (100)	82·9	7	7	—	42·3	10	1·4	66·4	1	113
3		70 (65) / 95 (100)	87·9	13	5	28	—	0	0·0	50·1	4	121

* See note, Table 4.

hensive results have only been obtained at two sets of temperatures, but in the case of *Schistocerca* adults sufficient experiments were carried out at all three sets of temperatures to enable most of the results to be produced in graphic form.



25

Fig. 25.—The effect of alternating relative humidities at different alternating temperatures (calculated to give weighted mean humidities and temperatures) on the length of life of adults of *Locusta*.

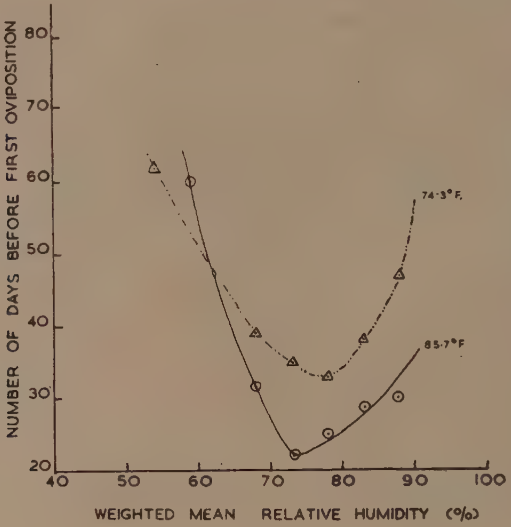
(a) *Locusta*.

Table 9 gives detailed records of the effect of alternating temperatures and humidities on the adults of this species.

The curves showing the effect of humidity on the length of adult life (fig. 25) are of the bimodal character similar to those for constant conditions, but the variable portions of the curves are more compressed within a shorter range of humidity. The optimum for both temperatures (weighted mean of 74·3° F.

and 85·7° F.) occurs at a weighted mean humidity of 78%, whereas under constant conditions the optimum was at 70% (fig. 15). The portions of the curves at the low calculated humidities are more drawn out than under constant conditions. This shows that under alternating conditions the short periods passed at a suitable humidity are sufficient to enable the locusts to survive longer at low average humidities than under constant conditions, but if these curves are studied along with those for sexual maturation (fig. 26), it will be seen that at some of these low average humidities adults never reached sexual maturity.

The point to be observed here is the variation in the optimal humidities. In the case of the weighted mean temperature of 74·3° F. the optimal humidity for length of adult life and time required to reach sexual maturity is 78% for both curves, but at a weighted mean temperature of 85·7° F. the optimal humidity for length of adult life is also 78%, while the optimum for rate of sexual maturation is approximately 73%. The curves for the average egg pods per female (fig. 27) show optima at calculated average humidities slightly different from those above but not sufficient to be significant.



26

FIG. 26.—The effect of alternating relative humidities at different alternating temperatures (calculated to give weighted mean relative humidities and temperatures) on the time required for *Locusta* to reach sexual maturity.

These optimal points on the curves may therefore be regarded as representing the effect of temperature, and having obtained them it is now possible to compare them with those obtained under constant conditions.

Unfortunately there are no constant temperatures which are exactly the same as the weighted mean temperatures, but from the point of view of comparison it is sufficient if the results obtained at temperatures alternating between 90° F. and 68° F., giving a weighted mean temperature of 74·3° F. (23·5° C.) are compared with the results at a constant temperature of 75° F. (23·9° C.). In the case of the results obtained at temperatures alternating between 100° F. and 80° F. giving a weighted mean temperature of 85·7° F. (30·9° C.), there are no results at temperatures sufficiently close that they could be used for comparison. Therefore the only possible solution is to compare them with hypothetical results at 85° F. obtained by taking the mean of results at constant temperatures of 80° F. and 90° F.

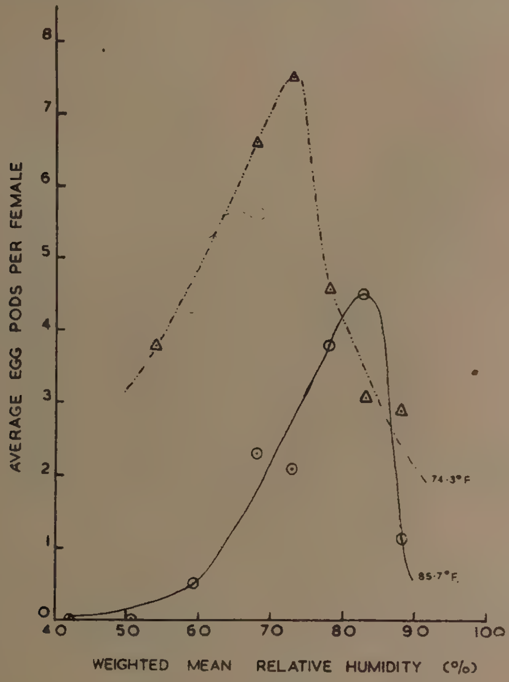


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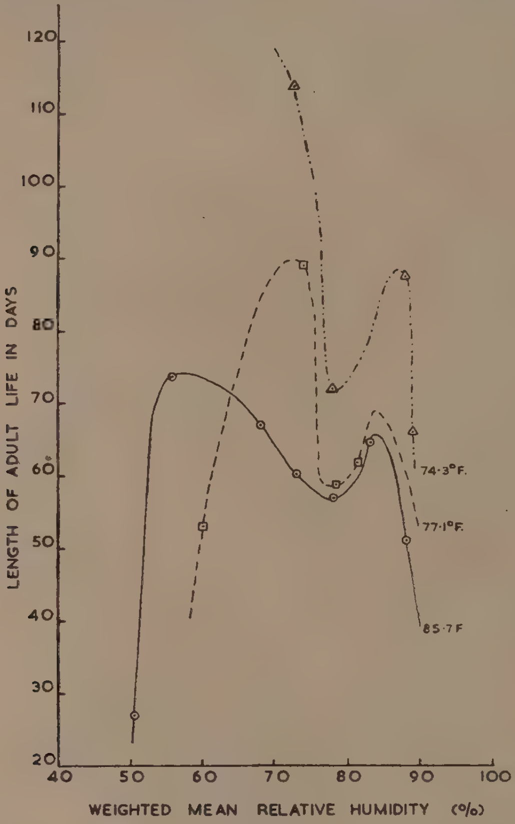
Fig. 27.—The effect of alternating relative humidities at different alternating temperatures (calculated to give weighted mean relative humidities and temperatures) on the average number of egg pods per female of *Locusta*.

On making a comparison between the results obtained at a weighted mean temperature of 74·3° F. (Table 9 and fig. 25) and a constant temperature of 75° F., it can be seen that the optimal length of life at the former temperature is 98 days, whereas at the latter temperature it is 60 days (Table 7). Sexual maturation occurs in 33 days at a weighted mean temperature of 74·3° F., and in 34 days at a constant temperature of 75° F.; thus under alternating conditions survival is longer at the optimal point than under constant conditions, but the rate of sexual maturation is the same. Therefore the time required to reach sexual maturity is dependent on degree hours, either alternating or constant. Perhaps the most interesting feature is the much higher number of egg pods (7·5) per female (fig. 27) at the weighted mean temperature of 74·3° F., compared with the 3·7 per female at constant temperature of 75° F. This result is explained by the length of adult life being much longer under alternating conditions than under constant conditions. This 7·5 egg pods per female is



28

FIG. 28.—The effect of alternating relative humidities at different alternating temperatures (calculated to give weighted mean relative humidities and temperatures) on the length of life of adults of *Schistocerca.*

the highest average egg pods for either species at any temperature, which demonstrates the effect of suitable alternating temperatures and humidities on fecundity.

Comparing the results at a weighted mean temperature of 85·7° F. with the mean of those obtained at constant temperatures of 80° F. and 90° F. (mean 85° F.), it is found that the optimum for length of life at 85·7° F. is 66 days (fig. 25), compared with 44·5 days at a mean constant temperature of 85° F. (fig. 15). Thus there is a difference of 21·5 days, but the time required to reach sexual maturity is the same (22 days) at both temperatures. This is very similar to the previous results, and shows that the mean of 80° F. and 90° F. is a justifiable figure to use for comparison. If the maximum egg pods per female at 85·7° F. and 85° F. are compared it will be seen that they are 4·5 and 3·7 respectively, which shows that alternating conditions give a result which is 0·8 better than the mean of constant temperatures. Here, again, it can be seen that the time required to reach sexual maturity is dependent on degree hours, whereas the number of egg pods per female depends upon the length of life of the adults at optimal conditions.

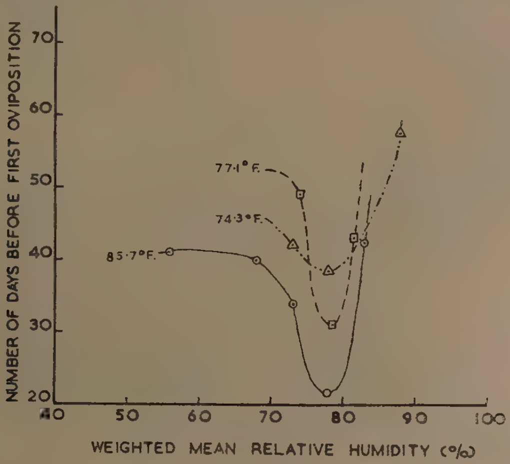


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Fig. 29.—The effect of alternating relative humidities at different alternating temperatures (calculated to give weighted mean humidities and temperatures) on the time required for *Schistocerca* to reach sexual maturity.

(b) *Schistocerca.*

The details of the effect of alternating temperatures and humidities on the adults of this species are given in Table 10. They are such that it has been possible to produce graphs (figs. 28 and 29) showing the effect on the length of adult life and time required to reach sexual maturity at three sets of temperatures—at 90° F. and 68° F., at 100° F. and 68° F., and at 100° F. and 80° F., giving respectively weighted mean temperatures of 74·3° F. (23·5° C.), 77·1° F. (25·1° C.) and 85·7° F. (30·9° C.). It has, however, only been possible to draw curves showing the average number of egg pods per female at the last two temperatures (fig. 30). Figure 28 shows that by the use of alternating temperatures and humidities it was possible to reduce the weighted mean relative humidity so low, in two experiments, that the length of adult life was shortened, and sexual maturity never occurred, thus two of the curves are of the bimodal type. The optimal point following sexual maturity is at 78% relative humidity for all three curves. Likewise the minimum time required for sexual maturation (fig. 29) and the maximum average egg pods per female (fig. 30) occur at the same weighted mean humidity. These optima at the weighted mean humidity of 78% may be taken as showing the effect of temperature. If the results are compared with those obtained under constant conditions, it will be seen that they do not, as in the case of *Locusta*, show any definite difference. For example, the optima for length of adult life, following sexual maturity, and the time required to reach sexual maturity, fluctuate so much that the figures are sometimes higher and sometimes lower than would be expected from the results when conditions were constant. The number of egg pods per female varies so much that no conclusions can be drawn. Also this species produced the highest number of egg pods (4·6) per female at a constant temperature of 90° F., whereas in the case of the *Locusta* it was at a weighted mean temperature of 74·3° F. These variations would suggest that the controlling factor for *Schistocerca* is one of degree-hours as far as temperature is concerned, but it must be remembered that this species is more susceptible to humidity changes than *Locusta.*

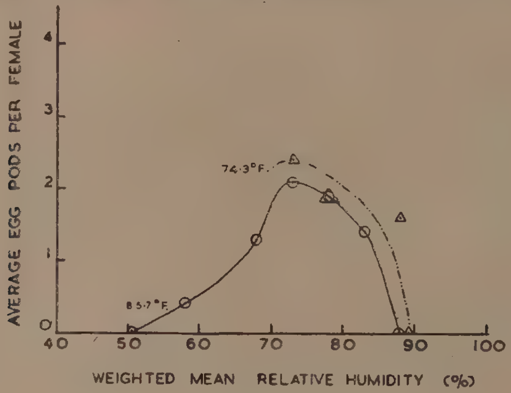

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Fig. 30.—The effect of alternating relative humidities at different alternating temperatures (calculated to give weighted mean humidities and temperatures) on the average number of egg pods per female of *Schistocerca.*

VI. The Effect of Temperature on Number of Eggs per Egg Pod, on the Percentage which Hatch and on the Time Required for Incubation.

When this investigation started it was thought that the number of egg pods per female could be regarded as a measure of fecundity at any particular temperature, and this was the method used for some time. However, as the experiments proceeded it was noticed that very few of the egg-pods produced at 110° F. ever hatched, and when they did hatch, as in the case of *Locusta,* the number of hoppers per egg pod was very small. It was therefore decided to keep a record of the number of hoppers which hatched from sample egg pods incubated at different temperatures under suitable conditions of relative humidity. These temperatures were the same as those for development and oviposition. A complete set of these results is given in Tables 11 to 14, and in figs. 31 and 32. Later it was found that even this method did not give a satisfactory record of fecundity, so it was then decided to count the number of eggs which failed to hatch, and this plus the number which hatched gave a complete record of the number of eggs per egg pod. It is regretted that the results in these columns are incomplete, but sufficient were obtained to show that temperature has an effect on the number of eggs per egg pod, as well as on the number of hoppers which hatch. This shows that it is not a question of incubation temperature.

TABLE 11.

Table showing the effect of constant temperature on the number of hoppers and eggs per egg pod of *Locusta*.

Number of egg pods.	Temperature (° F.)	Average incubation period in days.	Number of hoppers per egg pod.			Average unhatched eggs per egg pod.	Eggs per egg pod.		
			Average.	Min.	Max.		Average.	Min.	Max.
7	80	15·0	41·9	15	54	0·9	42·8	17	54
115	90	12·9	28·1	15	48	3·7	31·8	18	48
22	100	12·6	25·2	20	42		No figures available.		
9	110	12·2	14·4	10	34		"	"	

TABLE 12.

Table showing the effect of alternating temperature on the number of hoppers and eggs per egg pod of *Locusta*.

Number of egg pods.	Temperature (° F.) alternating between—	Weighted mean temperature (° F.).	Average incubation period in days.	Number of hoppers per egg pod.			Average unhatched eggs per egg pod.	Eggs per egg pod.		
				Average.	Min.	Max.		Average.	Min.	Max.
57	90–68	74·3	22·3	25·9	6	51	6·6	32·5	24	56
17	100–68	77·1	19·2	44·4	15	54	0·2	44·6	22	56
135	100–80	85·7	13·8	29·9	4	53	2·4	32·3	19	53

TABLE 13.

Table showing the effect of constant temperature on the number of hoppers and eggs per egg pod of *Schistocerca*.

Number of egg pods.	Temperature (° F.).	Average incubation period in days.	Number of hoppers per egg pod.			Average unhatched eggs per egg pod.	Eggs per egg pod.		
			Average.	Min.	Max.		Average.	Min.	Max.
6	80	16·0	22·3	18	24		No figures available.		
32	90	13·8	36·5	11	67	6·2	42·7	18	67
40	100	12·5	28·2	11	41	9·6	37·8	24	50
1	110	—	0	—	—	—	—	—	—

TABLE 14.

Table showing the effect of alternating temperature on the number of hoppers and eggs per egg pod of *Schistocerca*.

Number of egg pods.	Temperature (° F.) alternating between—	Weighted mean temperature (° F.).	Average incubation period in days.	Number of hoppers per egg pod.			Average unhatched eggs per egg pod.	Eggs per egg pod.		
				Average.	Min.	Max.		Average.	Min.	Max.
30	90–68	74·3	24·0	41·4	2	66	8·2	49·6	25	68
13	100–68	77·1	17·7	33·7	10	55		No figures available.		
35	100–80	85·7	15·1	28·0	8	53	11·7	39·7	30	59

As these results are from sample egg pods no account has been taken of the egg pods which failed to produce hoppers. This was done because sometimes egg pods were deposited on the perforated zinc floor of the cage and not in the sand in the tubes provided. Such egg pods could not be considered as they were not properly protected.

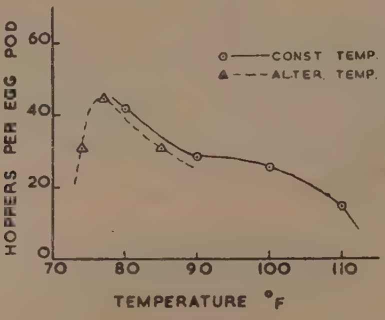

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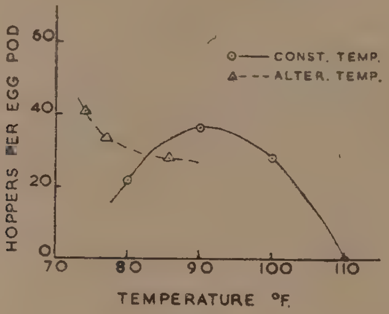
Fig. 31.—The effect of constant and alternating (calculated to give a weighted mean) temperatures on the average number of *Locusta* hoppers hatching per egg pod.



32

Fig. 32.—The effect of constant and alternating (calculated to give a weighted mean) temperatures on the average number of *Schistocerca* hoppers hatching per egg pod.

As the records for numbers of hoppers per egg pod are available for all temperatures these will be considered first. In the case of *Locusta*, under constant temperature conditions (Table 11 and fig. 31), it can be seen that 80° F. gives the highest average hoppers per pod. With an increase in the temperature to 90° F. there is a marked decrease, followed by successive decreases at 100° F. and at 110° F. Not only is there a decrease in the average hatch, but there is also a decrease in the maximum hatch as the temperature is increased. These decreases in the maximum hatch are gradual from 80° to 100° F., but at 110° F. there is a very marked decrease. Although the decrease in the average and maximum hatch is marked when the temperature is increased to 110° F., it is not as marked when sample egg pods are compared as it would have been if all egg pods deposited at all temperatures had been considered. Unfortunately, it is not possible to give figures for the actual number of pods which did not give any hatch, but it is possible to say that approximately 20% gave no hatch at 110° F., compared with approximately 2% at 80° and 90° F. Thus the total fecundity at 90° F. is very much greater than at 110° F.

Considering the results for *Locusta* (Table 12 and fig. 31) under alternating temperatures, giving weighted mean temperatures of 85·7° F., 77·1° F. and 74·3° F., the increase in the average number of hoppers hatching per egg pod, found when conditions were constant, goes on increasing until a weighted mean temperature of 77·1° F. is reached, when the average is 44·4. Then it drops to an average of 25·9 per egg pod at a weighted mean temperature of 74·3° F. Here, again, the maximum hoppers per egg pod at any temperature varies in the same way as the average hoppers per egg pod.

The results of experiments on *Schistocerca* show quite a variation from those on *Locusta*. Under constant temperature conditions (Table 13 and fig. 32) the average number of hoppers per egg pod was highest (36·5 hoppers) at 90° F. and dropped to 22·3 at 80° F. and 28·2 at 100° F. Likewise the maximum number of hoppers was highest at 90° F., with corresponding drops at 80° F. and 100° F. In the case of this species high temperature inhibits fecundity more than in the case of *Locusta*, as only one egg pod was ever produced at 110° F., and this never hatched. All the results of experiments on *Schistocerca* show that the temperature range is much smaller than for *Locusta*.

Turning to the results for *Schistocerca* at alternating temperatures giving weighted mean temperatures of 85·7° F., 77·1° F and 74·3° F. (Table 14 and fig. 32), the maximum number (41·4) of hoppers hatching per egg pod occurred at 74·3° F., followed by 33·7 and 28·0 hoppers at 77·1° F. and 85·7° F. respectively. Thus, under alternating conditions the optimal temperature is the lowest weighted mean temperature used in the experiments, and not the one (85·7° F.) nearest to the optimal temperature (90° F.) for constant conditions. The results for constant and weighted mean temperatures therefore form separate series, and are in no way continuous as in the case of *Locusta*.

The results giving the number of eggs per egg pod (*Locusta*, Tables 11 and 12, *Schistocerca*, Tables 13 and 14), although incomplete, show that the number of hoppers hatching per egg pod is primarily dependent upon the number of eggs deposited in each egg pod. A secondary factor influencing the number of hoppers per egg pod is temperature during incubation ; temperatures which are unfavourable for egg production show a higher number of non-hatching eggs, and so the number of hoppers hatching per egg pod accentuates the effect of temperature.

Without exception, all experiments show that the time required for incubation of locust eggs decreases as the temperature increases (figs. 33 and 34), but the decrease is not in proportion to the increase in temperature ; for example, in the case of *Locusta* eggs the difference in the incubation period at 80° F. and at 90° F. is 2·1 days, whereas between 90° F. and 100° F. it is 0·3 of a day (Table 11). In the case of *Schistocerca* (Table 13) the difference in the time required at the same temperatures is 2·2 and 1·3 days respectively. Thus the results under constant temperatures indicate that it is not a question of degree hours, yet when a comparison is made between a definite constant temperature and the corresponding weighted mean temperature (Tables 12 and 14), the time of incubation is approximately the same. Therefore for any given temperature, constant or weighted mean, the rate of development is a question of degree hours.

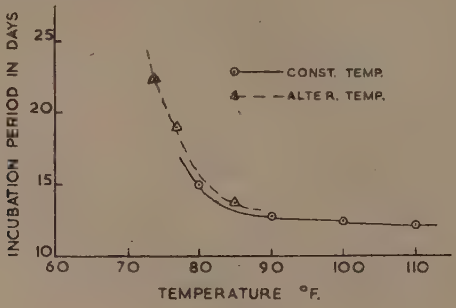


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Fig. 33.—The effect of constant and alternating (calculated to give a weighted mean) temperatures on the incubation period of eggs of *Locusta.*

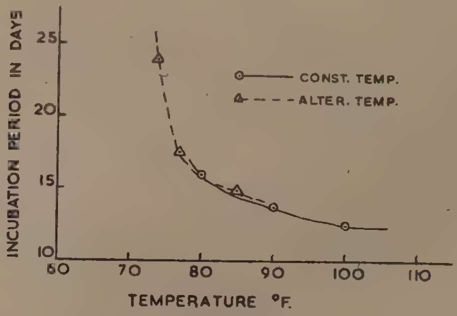

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Fig. 34.—The effect of constant and alternating (calculated to give a weighted mean) temperatures on the incubation period of eggs of *Schistocerca.*

VII. Discussion and Conclusions.

The distribution of both species of locusts (*Locusta migratoria migratorioides* and *Schistocerca gregaria*) is so wide that there is considerable variation in the relative humidity and temperature to which they are exposed. These variations have different effects on different species and on different stages (i.e. hopper, adult, or egg) of any one species.

The Effect of Constant Conditions on Hoppers.

Provided the temperature is kept constant, within the range suitable for development, then relative humidity directly affects the rate of growth and percentage of hoppers reaching the adult stage (Tables 1 and 2, figs. 1 to 9).

Both *Locusta* and *Schistocerca* hoppers develop faster, and a higher percentage reach the adult stage, when the relative humidity is between 60% and 70% than when it is below or above these limits. It should, however, be noted that each temperature (figs. 1, 2, 6 and 7) has a very slightly different optimum within this range of relative humidity. As the relative humidity decreases below 60%, or increases above 70%, the time required for development is increased, and the percentage of hoppers reaching the adult stage is reduced, until a humidity (either low or high) is reached at which the hoppers only survive a few days and never reach the adult stage. The precise relative humidity at which this occurs varies with temperature and species. At 110° F. (43·3° C.) no *Locusta* hoppers reach the adult stage at or below a relative humidity of 40%, whereas at 80° F. (26·7° C.) and 90° F. (32·2° C.) a reasonable percentage reach the adult stage when the relative humidity is as low as 35%, and it is not until 25% that no hoppers reach the adult stage. At the upper limits of relative humidity hoppers are unable to reach the adult stage at 85%, when the temperature is 110° F. (43·3° C.), but can do so at 100° F. (38·7° C.) and below.

No *Schistocerca* hoppers reach the adult stage at 100° F. or 90° F. if the relative humidity is 35%, but can do so at this relative humidity when the temperature is 80° F. At the upper limit, hoppers develop and reach the adult stage at a relative humidity of 85% when the temperature is 80° F., but fail to do so when the temperature is increased to 90° F. or 100° F. These results for *Schistocerca* hoppers show a narrower range of relative humidity than in the case of *Locusta* hoppers.

These variations in the effect of relative humidity at different constant temperatures suggest that the different optimal relative humidities, and the lower limits of relative humidity, are explained by different rates of evaporation (Gunn 1933; Koidsumi 1934) at different temperatures. But this does not explain the different upper limits of relative humidity at different temperatures. A possible explanation of the latter is that an increase in temperature increases the oxygen requirement of the locust, and Koidsumi (1934) has shown that the respiratory rate decreases with an increase in relative humidity; therefore death may be caused by a shortage of oxygen.

Notwithstanding these deviations at the high relative humidities, when temperature is high, I am convinced that relative humidity plays a very important part in the development of hoppers of both species. These conclusions are supported by the findings of Zolotarevsky (1933 and 1938) working on *Schistocerca gregaria* and Holdaway (1932) working on *Tribolium confusum*, thus showing that humidity affects the development of insects living in very different habitats. On the other hand, my conclusions are contrary to the findings of Husain, Ahmed and Mathur (1940) and Chauvin (1941), working on *Schistocerca gregaria*. Husain, Ahmed and Mathur claim that their results "prove beyond doubt" that relative humidity has no effect on the development of hoppers. However, on examining their results I find that they are basing their statement on experiments with only a very small number (often only one) of hoppers, and without controlling the moisture content of the food, whereas mine are based on large numbers, with the moisture content of the food controlled. Also most of their experiments were carried out at the extreme limits of relative humidity. In the case of one experiment at a relative humidity of 60%, the 13·7 days for the last two hopper instars, given in their table (V), shows a marked difference from 19·2, 19·4 and 26·8 days at relative humidities of 45, 80 and 100% respectively, yet in their text they say, "the average duration for the last two hopper stages is the same, i.e. 19 days." Conclusions such as these cannot be accepted as evidence of the effect of relative humidity on the development of hoppers.

Chauvin (1941), who criticizes my former paper, states that in his experiments at 100° F. a relative humidity of 0% gave optimal results, and that his results gradually got worse as the humidity was increased to 45% and above, whereas I find that hoppers cannot survive unless the relative humidity is 45% or higher at this temperature. He says that my stock must have a different resistance from his, but as he did not control the moisture content of the food (lettuce with its roots in water) or the micro-climate around it, I would suggest that he did not test the true effect of relative humidity at all. Rubtzov (1935) and Kennedy (1937) found that hoppers are able to detect a difference in the relative humidity, and that they migrate from dry to more humid conditions; this supports my findings.

Temperature is often regarded as the primary factor, and relative humidity the secondary one in the development of insects, but, as has been shown above, relative humidity may be just as important as temperature. The true effect of temperature on the time required for development of hoppers and on the percentage of hoppers reaching the adult stage is given by the optimal humidity point on any curve (figs. 1 and 2 for *Locusta*, 6 and 7 for *Schistocerca*) at that temperature. These optima for development of hoppers are given in column 3 of Table 3, and from them it has been possible to produce equations, $(x - 53)(y - 9) = 635$ for *Locusta*, and $(x - 63)(y - 16) = 300$ for *Schistocerca*, which give the theoretical time required for development (y) at any temperature (x). Also these equations give the developmental zero, 53° F. (11·7° C.), for *Locusta* and 63° F. (17·2° C.) for *Schistocerca*, below which no development occurs. The theoretical time required for development at different temperatures, calculated from the equation, is given in column 2 of Table 3 and the curves drawn from this in fig. 3. Although these equations give developmental zero temperatures, it must be remembered that these are not lethal temperatures, as I found that hoppers are able to develop when kept at 35° F. (1·7° C.) during the night and 90° F. (32·2° C.) during the day. Hussein (1937) has shown that hoppers kept at 32° F. (0° C.) for 15 hours behaved normally when the temperature was increased above the specific developmental zero. Temperatures, in the field, have been recorded as low as 40·8° F. (4·9° C.) by Ballard, Mistikawi and Zoheiry (1932), 45° F. (7·2° C.) by Rao (1933), 49·1° F. (9·5° C.) by Zolotarevsky (1938), and according to meteorological records, temperatures in areas where both species of locusts flourish are often below the developmental zeroes given above, but only for a short time.

While the equations help in determining the developmental zero temperatures, they give little help in arriving at the upper limits of constant temperature at which development is possible. Theoretically these temperatures should be those at which *Locusta* hoppers reach the adult stage in 9 days and *Schistocerca* hoppers in 16 days, but the temperatures required to give such results are very much higher than living protoplasm can withstand. Therefore the upper limits of temperature must be derived from experimental evidence and from the figures showing the combined effect of humidity and temperature (figs. 4, 5, 8 and 9). In the case of *Locusta* hoppers 110° F. (i.e. highest temperature used in experiments) gives the fastest rate of development, but in the case of *Schistocerca* hoppers 100° F. gives a faster rate of development than 110° F. This would suggest that for *Schistocerca* at least, 110° F. is approaching the fatal upper limit. Also both species show a marked decrease in the percentage of hoppers reaching the adult stage at 110° F. as compared with lower temperatures. The lines showing the combined effect of relative humidity and temperature on the time required for development indicate that the upper limit for *Locusta* hoppers would be about 118° F. (47·8° C.), and for *Schistocerca* hoppers 114° F. (45·6° C.). These figures agree with the findings of Hussein, who has shown that paralysis, due to heat, sets in when the temperature is increased to 119° F. (48·3° C.) and 115° F. (46·1° C.) for *Locusta* and *Schistocerca* respectively. At optimal relative humidity the developmental range of constant air temperature for *Locusta* hoppers is 53° F. (11·7° C.) to 118° F. (47·8° C.), and for *Schistocerca* hoppers 63° F. (17·2° C.) to 114° F. (45·6° C.), thus showing that the range of temperature, like the range of relative humidity, is narrower for *Schistocerca* than for *Locusta*. This developmental zero for *Schistocerca* hoppers given by my equation lies within the range of 62·6° F. (17° C.) to 64·4° F. (18° C.) given by Husain and Ahmed (1936) for eggs, but is lower than the 68° F. (20° C.) which they give for *Schistocerca* hoppers. My upper limit of temperature for *Schistocerca* hoppers is in agreement with the upper limit, 114·8° F. (46° C.), which they give for both eggs and hoppers. Although, as shown above, it is possible to decrease the temperature below the developmental zero for a short period without causing any harm, I agree with Hussein (1937) and Telenga (1930) that even a slight increase in temperature above the range, for a very short period, causes death. Within the range of temperature for each species there is an optimal temperature for the minimum time required for hopper development, and one for the highest percentage of hoppers reaching the adult stage. The optimal temperature for the development of *Locusta* hoppers (fig. 4) is just below 110° F., perhaps 108° F. (42·2° C.), and for *Schistocerca* hoppers (fig. 8) it is just above 100° F., perhaps 101° F. (38·3° C.), the latter agreeing with the findings of Husain and Ahmad (1936). The optimal temperatures for the highest percentage of hoppers becoming adult (figs. 5 and 9) are 94° F. (34·4° C.) and 90° F. (32·2° C.) respectively. Around these central optimal points it is possible to get the same result at a number of different relative humidities and temperatures, as a change in either relative humidity or temperature, or both, will bring about a change in results.

The Effect of Alternating Conditions on Hoppers.

The results obtained under known alternating conditions of relative humidity and temperature (Tables 4 and 5) are very important because the time passed at each relative humidity and temperature is known, therefore weighted mean relative humidities and temperatures can be calculated (figs. 11, 12, 13 and 14) and a comparison made with results obtained under constant conditions. Also they enable a direct comparison to be made between results obtained in the field and in the laboratory.

Alternating relative humidities extend the weighted mean relative humidity beyond the range possible when the relative humidity is constant (*cf.* figs. 1 and 2 with 11 and 12, and figs. 6 and 7 with 13 and 14). This is due to the fact that part of the life of the hoppers is passed at a favourable humidity, during which time they can recover from the effects of unfavourable humidity, and so survive and develop. The extension of the range of relative humidity, and the smoothness of the curves, indicate that alternating conditions reduce the intensity of the effect of humidity. Also the results show that the optimal weighted mean relative humidities, at the different temperatures, for hopper development and for the percentage of hoppers reaching the adult stage are all approximately between 70% and 80% for both *Locusta* and *Schistocerca*; this is slightly higher than when conditions are constant. Zolotarevsky (1933) found that hoppers prefer a relative humidity of 70% in the field. My experiments show that for hopper development it is more important to have a favourable (55–60%) relative humidity during the day when the hoppers are active and feeding, and an unfavourable (80-85%) relative humidity during the night, when they are inactive, than to have it unfavourable (35–40%) during the day and favourable (55 60%) during the night. Although the lower and upper limits of weighted mean relative humidities have been reached, in my experiments, for some weighted mean temperatures, the curves show little indication (especially at the lower limits) of flattening such as occurs when conditions are constant. This indicates that alternating conditions other than those tested in my experiments, and often found in the field (Maxwell-Darling 1937, Meteorological records, etc.), may enable hoppers to develop over a still wider range of humidity.

The optimal points on the curves in figs. 11 and 13 show the effect of temperature on the time required for hopper development. These optimal points are given for both species in column 4, Table 6, where they can be compared with the best experimental results in column 3, and the theoretical results in column 2. All three agree (within the limits of experimental error), thus showing that the rate of development of hoppers of both species is one of degree hours, above the developmental zero, provided the humidity is at the optimum.

The highest percentage of hoppers reaching the adult stage (figs. 12 and 14) occurs at 85·7° F. (30·9° C.) for both species, but as this is the highest weighted mean temperature used in the experiments it is unknown what would happen at higher weighted mean temperatures. In *Locusta* the percentage of hoppers which reach the adult stage at 85·7° F. is 78; this is between the percentages at constant temperatures of 80° F. and 90° F., whereas in the case of *Schistocerca* only 53% of the hoppers reached the adult stage at this temperature, which is nearer the results at a constant temperature of 80° F. than at 90° F. This indicates that no stimulus results from alternating conditions, but when temperatures pass below the favourable range, then a weighted mean temperature of 74·3° F. (23·5° C.) gives a better result than a constant temperature of 75° F., therefore indicating that alternating conditions extend the range of temperature, as in the case of alternating and constant relative humidities.

Although no attempt has been made to join the points (given in small type in figs. 4 and 5 for *Locusta* and 8 and 9 for *Schistocerca*) showing the combined effect of weighted mean relative humidities and temperatures on the time required for hopper development, and on the percentage of hoppers reaching the adult stage, it can be seen from them that better results are obtained at low weighted mean temperatures than at low constant temperature, and that the range of humidity is wider. Also the best results are obtained when conditions are favourable during the day (i.e. medium humidity and temperature) and unfavourable during the night (i.e. high humidity and low temperature). These are generally the conditions in the field during the development of hoppers (Lean 1931, Ballard, Mistikawi and Zoheiry 1932, Rao 1933, Golding 1934, Maxwell-Darling 1936 and 1937, Zolotarevsky and Murat 1938).

Zolotarevsky (1938) carried out some semi-field experiments under fluctuating conditions, the results of which agree in principle with mine. His results at average relative humidities of 35%, 45% and 70% agree with my results as regards survival of hoppers, but he found that he was able to rear hoppers at a relative humidity of 100%, whereas I was not able to do so, even at weighted mean relative humidities slightly below 100%. As I found it impossible to maintain a relative humidity of 100% in an enclosed space when temperatures were alternating, I suggest that his average relative humidity must have been below the 100% mark. The rate of development which he found at an average daily temperature of 86·0–91·4° F. (30–33° C.) is slightly slower than I would have expected if the relative humidity had been at the optimum. Judging from my results, it would seem that his average daily temperature is not based on degree hours, and therefore is perhaps a little higher than a true weighted mean temperature, which would account for the difference in our results.

The Effect of Constant Conditions on Adults.

When studying the effect of relative humidity and temperature on adult locusts, it is essential that the length of adult life, the time required to reach sexual maturity, the average number of egg pods per female and the number of hoppers which hatch from the egg pods (Tables 7, 8 and 11–14, figs. 15–24) are taken into consideration. If this is done then the cumulative effect of humidity and temperature can be fully appreciated.

In my previous paper (1936) I assumed, from the then known results, that the duration of adult life was shortest when conditions were optimum for sexual maturation, and that the length of life gradually increased as conditions became less favourable. As the result of additional experiments this latter assumption must be modified. In fig. 15 the curves showing the effect of relative humidity on length of life of adult *Locusta* are bimodal in nature for all temperatures. They all show a point at 70% relative humidity where the length of life is very short. This corresponds with the relative humidity (fig. 16) at which the time required to reach sexual maturity is shortest, and it is very close to the optimal relative humidity (varies from 70% to 75% according to temperature) for maximum egg pods per female. Thus the optimal relative humidity may be taken as 70%. As the relative humidity is slightly increased above, or decreased below, this figure, the time required to reach sexual maturity increases (fig. 16), so does the length of adult life (fig. 15), but the number of egg pods decreases (fig. 18). This shows that with an increase in the average number of days required to produce the first egg pod there is an increase in the length of adult life. But when the relative humidity is increased to between

77% and 80%, or decreased to between 45% and 60%, depending on temperature, then the time required to reach sexual maturity is greatly increased and the number of egg pods small or none at all. Beyond these ranges the length of adult life begins to decrease, due to unfavourable humidities, causing death before sexual maturation takes place.

These results at the lower limits of relative humidity are very interesting and important because they show that there is no adult diapause due to low humidity (*cf. Schistocerca*), and if the relative humidity prevents sexual maturation, adults of *Locusta*, even if kept at a suitable constant temperature, all die within approximately four months (maximum length of adult life, Table 7) without ovipositing. These experiments on the adults were carried out at approximately the same relative humidities as those at which the hoppers developed, thus showing that hoppers can develop at lower relative humidities than those at which adults can become sexually mature.

My experiments on adults of *Schistocerca* (figs. 20–24) show that this species is, on the whole, more sensitive to changes in humidity than *Locusta*. Also there is a greater variation in the optimal relative humidities for length of adult life, for time required to reach sexual maturity and for the number of egg pods per female, but all are sufficiently close to assume that a relative humidity of between 65% and 70% would give optimal results. As the relative humidity is slightly increased above the optimum, the length of adult life increases, also the time required to reach sexual maturity, but the number of egg pods per female decreases until a point is reached, just as with *Locusta*, at which the length of adult life begins to decrease due to an unfavourable high relative humidity. The higher the temperature the higher the relative humidity before the length of adult life begins to decrease. This shows that at high relative humidities both species respond in very much the same way to changes in relative humidity, but at relative humidities below the optimum there is a marked difference in the reaction of the two species. When the relative humidity is slightly reduced, the length of adult life and the time required to reach sexual maturity increase and the number of egg pods per female decreases, as in *Locusta*. But when the relative humidity is greatly reduced sexual maturation does not occur, a diapause due to a low relative humidity sets in, and the length of adult life goes on increasing, whereas in *Locusta*, when the relative humidity is too low for sexual maturation, the length of adult life is short. In *Schistocerca* this diapause seems to set in at a constant relative humidity of approximately 40%, at 90° F., because in one of the two experiments at this relative humidity (Table 8) sexual maturation occurred, while in the other it did not. This shows that, although it is possible to rear *Schistocerca* hoppers at this relative humidity or even a little lower (35%, Table 2), it is doubtful if sexual maturation will occur unless the humidity is increased. In my paper (1936) I showed that it was possible to keep adults of *Schistocerca* for four months at 30% relative humidity, at 90° F., without sexual maturation occurring, and then when placed in a suitable higher relative humidity they became sexually mature in approximately the same time as did newly emerged adults. (A further discussion on the effect of relative humidity will be found under alternating conditions, p. 52.)

The effect of temperature on adult locusts, as in the case of hoppers, varies considerably, and there is no one temperature which is an optimum for all functions of adult life. Considering first the effect of temperature on length of adult life, it is very difficult to define what is meant by the optimal temperature. A low temperature which prolongs the length of adult life, but does not bring about sexual maturity, cannot be regarded as optimum; nor can one which is so high that it causes sterility and death in a few days.

My experiments on *Locusta* (Table 7) show that the shortest time (12 days) required for sexual maturation (fig. 16) at optimum humidity occurs at 100° F. (37·8° C.), followed by 15, 18, 25 and 33 days at 110°, 90°, 80° and 70° F. respectively. The lines in fig. 17 indicate that the optimal temperature for sexual maturation is 103° F. (39·4° C.). In my experiments the maximum number of egg pods (4·7) per female was produced at a constant temperature of 90° F. (32·3° C.), but again a study of the combined effect of relative humidity and temperature places the optimum (fig. 19) at 93° F. (33·9° C.). An interesting point to be noted here is the similarity of this temperature to the temperature (94° F.) which is the optimum for the percentage of hoppers reaching the adult stage.

In the case of *Schistocerca* the shortest time required for sexual maturation is 17 days at 100° F., followed by 26, 27 and 50 days at 90°, 80° and 110 respectively, which shows that for this species (*cf. Locusta*) 110° F. is much too high. Judging from the lines in figure 22 the optimal temperature for sexual maturation is 98° F. (36·7° C.). This is supported by the fact that I (1936) found that this species died out if kept at 100° F. for a number of generations. The optimal temperature for maximum egg pods per *Schistocerca* female is 94° F. (34·4° C.), which is the same as the optimum for maximum hoppers reaching the adult stage. Thus the results show that in both species quantitative activities (i.e. number of hoppers reaching the adult stage and number of egg pods per female) have approximately the same optimal temperatures. Speed activities (i.e. rate of hopper development and sexual maturation of adults) have higher optimal temperatures.

Although the range of temperatures employed in these experiments on adults was limited to temperatures at which hoppers had been reared, it is reasonable to assume that the upper limit would be very similar to that for hoppers, i.e. 118° F. (47·8° C.) for *Locusta* and 114° F. (45·6° C.) for *Schistocerca*. This assumption is based on the fact that the optimal temperatures for adults and hoppers are very similar, and on the general trend of the curves for adults. The figure which I give for *Schistocerca* is in agreement with that given by Husain and Ahmad (1936), but is considerably lower than the upper limit of diurnal fluctuations given by some authors, e.g. 131° F. (55° C.), given by Roubaud (1935), but it must be remembered that the temperatures which Husain and Ahmad and I give are constant. While I have no evidence to prove that adults could not withstand a constant temperature of 131° F., my results show that they would be sterile.

The Effect of Alternating Conditions on Adults.

The results obtained under these conditions show the same trend as those obtained under constant conditions.

The curves for *Locusta*, showing the effect of weighted mean relative humidities on the length of adult life (fig. 25), have the same bimodal character as for constant conditions, but the length of life is, on the whole, slightly longer. These curves show that there is a weighted mean relative humidity range of 70% to 85%, where conditions are favourable throughout the 24 hours of the day. These results agree fairly well with those of Zolotarevsky (1938), who gives the favourable range of relative humidity as 60% to 80%, but as his are field results this slight difference may be due to greater variation, and to longer exposure to the lower daytime humidity. He gives 70% relative humidity as the optimum, which is the same as my results under constant conditions, but lower than the 75% weighted mean relative humidity which I consider to be the optimum, and which is more in keeping with the findings of Lean (1931*a*). Judging from the nature of these curves, it is obvious that alternating conditions produce more gradual curves than constant conditions, and the curves extend to a much higher relative humidity than is possible when conditions are constant. This indicates that with adults, as with hoppers, it is more important to have favourable humidities during the day when locusts are active than at night when they are inactive at a low temperature. Alternating conditions such as these are experienced by the locust in the field. The upward extension of the range of weighted mean relative humidity for length of adult life also results in an extension of the range for sexual maturation (fig. 16) and for number of egg pods per female (fig. 18).

The results for *Schistocerca* adults (Table 10) are very similar to those for *Locusta* under corresponding conditions, but it is possible to be more precise, and state that the optimal weighted mean relative humidity is 78%. The curves for length of adult life (fig. 28) and for time required to reach sexual maturity (fig. 29) show that above this optimum an increase in the weighted mean relative humidity causes both the length of adult life and the time required for sexual maturation to increase at first; but when the weighted mean relative humidity is 85% or above, the length of adult life shortens as the result of very unfavourable humidities, and death occurs without sexual maturation having taken place. This is very similar to results under constant conditions, but at a higher humidity. Below the optimal weighted mean relative humidity there is, at first, a gradual increase in the length of adult life and the time required to reach sexual maturity, but at weighted mean relative humidities below 60% at 77·1° F. and 50% at 85·7° F., the length of adult life begins to decrease as the result of unfavourable humidities, and the adults die without becoming sexually mature. Thus at weighted mean relative humidities, the curves for length of adult life have the same bimodal character as the curves for *Locusta* under all conditions, but are quite unlike the curves for *Schistocerca* at the lower limits of constant relative humidity. This difference in the effect of low constant and weighted mean relative humidities, in my experiments, is difficult to explain, because it is well known that adults of this species do not mature for a long time in the field, where conditions fluctuate, if the humidity is low, e.g. Zolotarevsky and Murat (1938). The only reason I can suggest for this difference in my results at low constant and alternating relative humidities, is that the times passed at the different alternating relative humidities were such that the vitality of the locust was used up without bringing about sexual maturation.

A comparison between the results on *Locusta* adults under alternating and constant conditions shows that they live longer at a weighted mean temperature than at the corresponding constant temperature, yet the time required for sexual maturation is the same ; thus the rate of sexual maturation is a question of degree hours. Linked with this increase in length of life I find an increase in the number of egg pods per female, which suggests that the number of egg pods at comparable temperatures is dependent on the length of adult life.

Results for *Schistocerca* under alternating conditions of temperature show that the time required for sexual maturation is shorter (*cf. Locusta*), and that there is a corresponding shortening in the length of adult life as compared with constant conditions. This speeding up of the rate of sexual maturation may be due to alternating temperatures stimulating sexual development, therefore the time required for sexual maturation in this species is not a question of degree hours as in the case of *Locusta*. In the field, day and night temperatures always alternate, therefore the only factor which is necessary is moisture, and it has been shown that when this is sufficiently high there is no diapause.

In both species the curves for the average number of egg pods per female show that at all weighted mean relative humidities (except one for *Schistocerca*) more egg pods are produced at a weighted mean temperature of 74·3° F. than at 85·7° F. This I believe to be due to the fact that at the latter temperature the upper limit is 100° F., which is not as suitable for the production of egg pods as an upper limit of 90° F. (*cf.* constant conditions).

The Effect of Temperature on the Number of Eggs per Egg Pod, the Number of Eggs which Hatch, and on the Incubation Period.

Although the humidity at which the egg pods are kept plays an important part (Bodenheimer 1930 and Hamilton 1936) in determining the percentage of eggs which hatch, temperature is also important. The effect of temperature may be direct (i.e. due to the temperature at which the eggs are incubated) or indirect (i.e. due to the temperature at which hoppers and adults are kept).

Locusta egg pods kept under constant temperature conditions (Table 11) give the highest average number (41·9) of hoppers at 80° F. As the temperature increases the number decreases. Under alternating conditions (Table 12) the results at weighted mean temperatures are very similar to those above, where the temperatures correspond (fig. 31) ; below the range of constant temperatures the number of hoppers hatching continues to increase as the weighted mean temperature decreases, up to 44·4 per egg pod at 77·1° F., and then it begins to drop. Thus it is possible to say that the overall optimum is just below 80° F., perhaps 78° F. When considering the effect of temperature on the number of hoppers which hatch from each egg pod, it must be remembered that approximately 80% of the egg pods failed to give any hatch at 110° F., compared with approximately 2% at 80° F. or 90° F., therefore the adverse effect of high temperature is greater than it actually appears in my results.

In the case of *Schistocerca* the results are not as straightforward as those for *Locusta*. Under constant conditions (Table 13) there is a definite optimum of 36·5 hoppers hatching per egg pod (fig. 32) at 90° F., and complete failure at 110° F. Thus the optimal temperature is much higher, yet the upper limit of temperature much lower, than for *Locusta*. The results for *Schistocerca* under alternating conditions (Table 14) are also quite different from those for *Locusta*, as they do not form a series with the constant temperature results.

This difference in the two species at first seems strange, but it demonstrates that for *Schistocerca* the upper and lower limits of temperature must be considered as well as the weighted mean temperature. For example, a weighted mean temperature of 74·3° F. (i.e. alternating between 90° F. and 68° F.) is much lower than a constant temperature of 80° F., yet fecundity is much higher. The two other weighted mean temperatures, 77·1° F. and 85·7° F., would seem more suitable, but in fact proved less favourable, than 74·3° F. This is obviously due to the fact that the higher weighted mean temperatures have an upper limit of 100° F., which is unfavourable for the production of egg pods with large numbers of eggs (*cf.* constant conditions). Therefore my experiments show that for *Locusta*, corresponding temperatures, whether constant or alternating, give approximately the same number of hoppers per egg pod, but in the case of *Schistocerca* alternating temperatures at the lower limits stimulate, while alternating temperatures with a high upper limit are deleterious.

A comparison between the number of hoppers which hatch, and the total number of eggs per egg pod (where figures are available), not only shows that more eggs fail to hatch, but that there is a definite reduction (Tables 11 to 14) in the total number of eggs per egg pod when temperatures are unfavourable. Ballard, Mistakawi and Zoheiry (1932) have shown that there is considerable variation in the number of *Schistocerca* eggs per egg pod, but do not attempt to correlate it with climatic conditions. The reduction in the percentage of eggs which hatch at very high temperatures may be due to the effect of temperature on the development of the embryos, or on spermatogenesis in the adult, with the result that some ova are not fertilized. Raichoudhury (1936) has shown that at high temperatures there is a retardation of spermatogenesis in *Ephestia kühniella* Zeller. The reduction in the number of eggs per egg pod at unfavourable temperatures may be due to a smaller number of ovarioles in the ovaries, as the result of unfavourable temperatures during the developmental stages, or to some of the ovarioles failing to contribute to each egg pod. Lopez (1933) has shown that there is considerable variation (48 to 80) in the number of ovarioles in *Locusta*, but suggests no reason for the variation, while Rubtzov (1934) states that the number of ovarioles in Siberian grasshoppers varies with climatic and food conditions. Phipps (1949), working on British grasshoppers, found a variation in some species but not in others, and suggests that the cause may be genetic, food supply, or climatic conditions. Although there may be individual variation in the number of ovarioles, this would not be sufficient to account for my results at different temperatures. In my opinion, failure of ovarioles to contribute eggs to each egg pod when conditions are unfavourable is the most likely reason for a reduction in the number of eggs at unfavourable high or low temperatures. Also it would be in keeping with the fact that at low weighted mean temperatures *Schistocerca* adults are stimulated to produce a greater number of eggs per egg pod than at a corresponding constant temperature.

In both species the incubation period decreases with a rise in temperature, irrespective of whether it is constant or weighted mean (figs. 33 and 34), but as the upper limits of temperature are approached the rate of increase slows down, until a point is reached at which there is no further increase in the rate of development, and finally the temperature becomes so high that development fails. This is very similar to the effect of temperature on hopper development and on sexual maturation. Also, as in the case of hoppers, the fatal upper limit is at a lower temperature for *Schistocerca* than for *Locusta*, again emphasizing that *Schistocerca* is less tolerant of high temperatures than *Locusta*, at all stages of its existence.

VIII. SUMMARY.

1. Experiments were carried out on hoppers and adults of *Locusta migratoria migratorioides* (R. & F.) and *Schistocerca gregaria* (Forsk.) at constant and alternating relative humidities and temperatures, and on eggs at constant and alternating temperatures. Alternating relative humidities and temperatures have been calculated to give weighted mean relative humidities and temperatures.

2. The limits of relative humidities between which hoppers develop and adults become sexually mature vary with temperature.

3. The possible range of temperature for the development of hoppers and eggs of *Locusta* is from 53° F. (11·7° C.) to 118° F. (47·8° C.), and for *Schistocerca* from 63° F. (17·2° C.) to 114° F. (45·6° C.). Although adults can survive within these ranges they become sterile if kept at very high constant temperatures (e.g. 110° F. (43·3° C.) for *Schistocerca*, and a little higher for *Locusta*).

4. The optimal constant relative humidity for the development of *Locusta* hoppers and for percentage of hoppers reaching the adult stage varies from 65% to 68%, depending on temperature, and for *Schistocerca* hoppers from 60% to 70%. The optimal weighted mean relative humidity for both species varies from 70% to 80%.

5. The optimal temperature for the development of hoppers is 108° F. (42·2° C.) for *Locusta* and 101° F. (38·3° C.) for *Schistocerca*.

6. The highest percentage of hoppers reaching the adult stage occurs at 94° F. (34·4° C.) for *Locusta* and 90° F. (32·2° C.) for *Schistocerca*.

7. The optimal constant relative humidity for sexual maturation and number of egg pods per female is 70% for *Locusta*, and between 65% and 70%, varying with temperature, for *Schistocerca*. The optimal weighted mean relative humidity is approximately 75% for *Locusta* and 78% for *Schistocerca*. At a constant relative humidity of 40% and below *Schistocerca* adults go into a diapause, whereas *Locusta* adults never show any sign of a diapause.

8. The optimal constant temperature for sexual maturation is 103° F. (39·4° C.) for *Locusta* and 98° F. (36·7° C.) for *Schistocerca*, while the maximum number of egg pods per female occurs at 93° F. (33·9° C.) for *Locusta* and 94° F. (34·4° C.) for *Schistocerca*. The optimal weighted mean temperature for sexual maturation is 85·7° F. (30·9° C.) (highest in my experiments) and for maximum number of egg pods per female is 74·3° F. (23·5° C.) (lowest in my experiments) for both species.

9. Within the range of relative humidity where sexual maturation occurs the length of adult life is closely linked with the time required to reach sexual maturity ; the faster the rate of sexual maturation the shorter the life.

10. The maximum number of eggs per egg pod and hoppers hatching occurs at a constant temperature of 80° F. (26·7° C.) for *Locusta* and 90° F. (32·2° C.) for *Schistocerca*, but at weighted mean temperatures of 77·1° F. (25·1° C.) for *Locusta* and 74·3° F. (23·5° C.) for *Schistocerca*. A comparison

between constant and alternating temperatures shows that both species deposit more eggs per egg pod when conditions are alternating than when they are constant.

11. In both species quantitative activities (i.e. number of hoppers reaching the adult stage and number of egg pods per female) have approximately the same optimal temperatures. Speed activities (i.e. rate of hopper development and sexual maturation of adults) have higher optimal temperatures, therefore no one temperature can be regarded as optimum for all functions of hopper and adult life.

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ON THE PLECOPTERA OF THE CAUCASUS.

By B. I. BALINSKY.

(Communicated by the Honorary Secretary.)

Manuscript received 31st August, 1948.
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With 21 Text-figures.

THE Plecopteran fauna of the Caucasus has not previously been adequately investigated, and up to the year 1927 only scattered information on the stoneflies of the Caucasus was available. In 1928 there appeared a paper by Martynov which represented the first attempt at a systematic investigation of stoneflies inhabiting the Caucasian mountain range. In this paper Martynov mentioned only six species of stoneflies, the occurrence of which in the Caucasus had been noted by previous investigators. These species were : *Perla pallida* Guer., *Perla caucasica* Guer., *Agnetina acutipennis* Klapálek, *Agnetina senilis* Klapálek, *Filchneria infumata* MacLachlan, *Capnia nigra* Pictet. The work was based on a collection of stoneflies from the vicinity of Vladikavkaz and from the resort Teberda. Unfortunately Martynov published only the first part dealing with the families NEMOURIDAE and LEUCTRIDAE. The proposed continuation, comprising descriptions of stoneflies of other families, never appeared, and after his death there was no successor who could complete his work on the Vladikavkasian collection. Martynov mentioned 14 species of Nemourids (*Protonemura mirabilis* Martynov, *Protonemura microstyla* Martynov, *P. capitata* Martynov, *P. dilatata* Martynov, *P. triangulata* Martynov, *P. breviuscula* Martynov, *P. falciformis* Martynov, *P. bifida* Martynov, *P. oreas* Martynov, *P. spinulata* Martynov, *Nemoura variegata* Oliv., *Nemoura pallida*—later renamed by Claassen as *N. martynovia*—*N. brevipennis* Martynov and *N. elegantula* Martynov) and 5 species of Leuctrids (*L. furcatella* Martynov. *L. tarnogradskii* Martynov, *L. uncinata* Martynov, *L. collaris* Martynov and *L. fusciventris* Stephens). Since the publication of Martynov's paper only one species has been added to the list of Caucasian stoneflies so far as I can ascertain. This species is *Esera caucasica* Navás (1931).

The stoneflies which I have been able to investigate were collected by me during several collecting trips to the Caucasian mountains. During these trips I visited the following localities : Nalchik (the capital of the Kabardino-Balkarian Republic), a number of alpine valleys in Balkaria to the east of Mount Elbrus (Chegem valley, Djilki-Su valley, Sokoshili-Su valley, Baksan valley, Adyr-Su valley, Terskol valley), the valley of the River Nakra in north Svanetia to the south of Mount Elbrus, and lastly the valley of the river Teberda, and several adjoining valleys in the Karachayev Land, to the west of Mount Elbrus. All these localities, except the Nakra valley, lie on the north slope of the Caucasian Mountain Range.

Relatively few of the stoneflies have been collected in the subalpine zone. By far the greater number were collected in the alpine zone, that is in the zone of forests which cover the north slope of the Caucasus up to an altitude of

2300–2400 metres, in the zone of shrubs, and above the zone of shrubs up to the snow line, which corresponds to an altitude of about 3000 metres on the north slope of the mountain range.

All the stoneflies were preserved in alcohol and formed part of my private collection. During the last war I was forced to leave my collection at the Institute of Fisheries of the University of Posnan (Poland). This included the

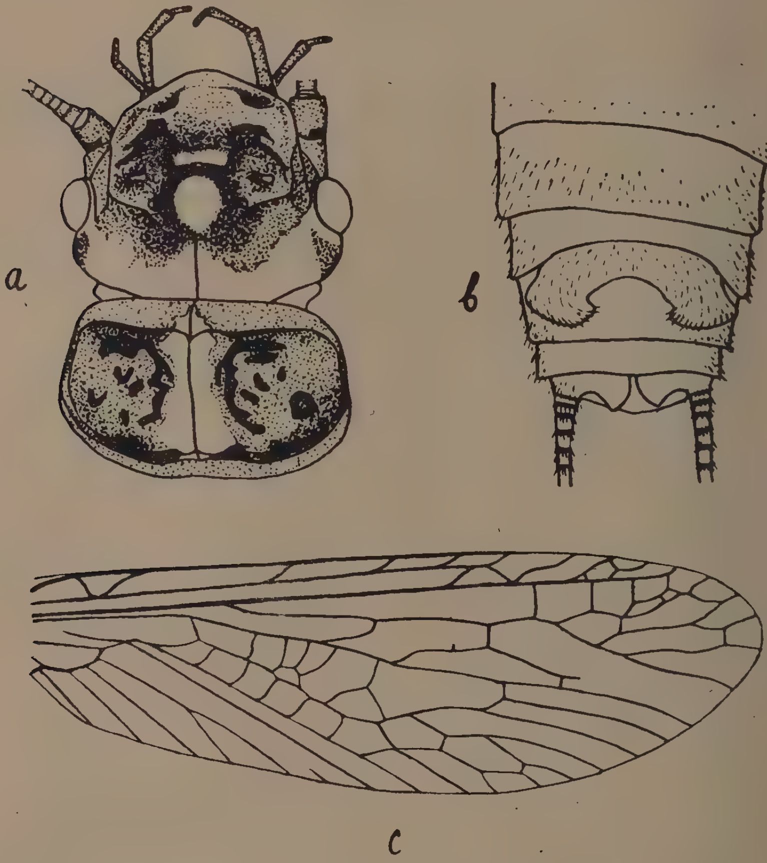

Fig. 1.—*Filchneria balcarica* sp. n. *a*, Head and prothorax; *b*, ventral view of abdomen (♀) with subgenital plate; *c*, venation of fore wing.

types of all the species described in the following pages. The collection has now been deposited in the Zoological Museum, Warsaw.

A study of my collection showed that it included at least 23 species of stoneflies. Thirteen of these have been described previously (nine by Martynov); ten species appear to be new and are described in this paper. The descriptions of species discovered by Martynov are not equally thorough. Some descriptions are insufficient, a few assertions are obviously fallacious, and I have therefore felt it necessary to give short characteristics and even complete redescriptions of some of his species. The Caucasian stonefly fauna is now represented by 37 species. The nomenclature I have followed is, as far as possible, that adopted by Claassen in his *Catalogue of the Plecoptera of the World* (1939).

Filchneria Klapálek.

Filchneria balcarica sp. n.

Antennae of an even brownish colour, the 9th joint relatively short. Head with rounded anterior angles; anterior margin produced in the middle as a very blunt angle (fig. 1, *a*). Dorsal surface of head dark brown; occipital region, an oval frontal spot, and a small transverse mark before middle of M-line bright yellow. Yellow field on the occiput reaches laterally to compound eyes, but there is a dark brown spot latero-caudally from each of the latter. Yellow streaks pass on each side from occipital field above compound eyes to base of antenna. Moderately large frontal tubercles lying transversely between ocelli and antennae adorned with small yellow spots. M-line more or less blurred. Two dark transverse depressions near anterior edge of clypeus. Distance between posterior ocelli related to distance between each of these and anterior ocellus as 22·5 : 14. Relation of distance between posterior ocelli and distance between each of these and compound eye is 22·5 : 13·0–15·0. Ventral surface of head yellow.

Pronotum broad (relation of breadth to length 1·35–1·38), narrower anteriorly, with rounded angles (fig. 1, *a*), chestnut brown, matt (only the callosities, which are otherwise not very conspicuous, glistening), with bright yellow median band. Median band relatively narrow; in its narrowest part (between the first and second third of its length) breadth is about $\frac{1}{8}$ of total breadth of pronotum. Meso- and metanotum black and glistening. Ventral surface of thorax yellowish white with dark brown chitinized parts. Basisternum and furcasternum fused (as in *Perlodes microcephala* Pictet, according to Kühtreiber, 1934). Legs brown, distal ends of tibiae and tarsus darker. On sides of femur chestnut brown stripes. Femur yellow at knee joint. Wings very darkened, brownish grey with dark brown, almost black venation. An irregular net of veins on apex of fore wing, between radius and radial sector (fig. 1, *c*). Radial sector branches from radius in proximal $\frac{1}{3}$ of fore wing. Interior interradial cell as long as or longer than its stalk. In medial field 5–6 and in cubital field 6–9 cross-veins; in cubital field of hind wing 2–3 cross veins. Anterior branch of second anal vein of hind wing bears 3 or 2 secondary branches (in the latter case the first bifurcates again).

Dorsal surface of abdomen dark brown, ventral surface reddish or yellowish brown. Subgenital plate of female very broad. A broad and deep incision on posterior margin subdivides the plate in two lateral lobes (fig. 1, *b*), the ends of which bear medially-directed rounded protrusions. Tenth tergite produced posteriorly in a blunt angle; a slight depression on its surface before the apex. Cerci uniform grayish or grayish brown colour, with rows of especially long hairs at ends of segments.

♂. Unknown.

Length of body 21–22·5 mm. *Length of fore wing* 21–21·5 mm.

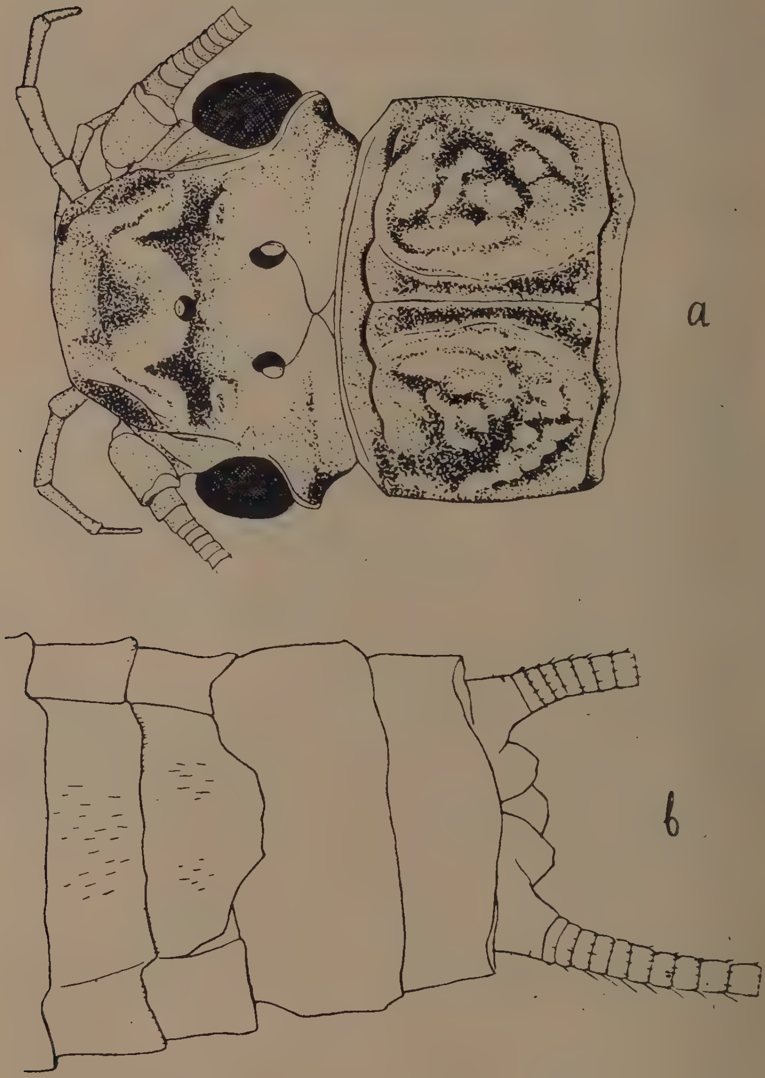

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Fig. 2.—*Agnetina senilis* Klapálek. *a*, Head and prothorax; *b*, ventral view of abdomen (♀) with subgenital plate.

BALKARIA: Djilki-Su, 15.vii.1932, 1 ♀ (stream); Adyr-Su valley, 14.viii.1939, 1 ♀.

This species differs from all other members of the genus *Filchneria* in possessing medially-directed protrusions on the lateral lobes of the subgenital plate. Other species of the genus are known from Mongolia (*F. mongolica* Klapálek), from the Baikal (*F. clementi* Navás), from Tien Shan (*F. furcifera* Navás) and from Tibet and Sikkim (*F. uncata* Kimmins). One species has been described from the Caucasus (*F. infumata* MacLachlan). It appears, therefore, that *F. balcarica*, together with *F. infumata*, represent a Central Asiatic element in the Caucasian fauna.

Agnetina Klapálek.

Agnetina senilis Klapálek.

KABARDINO-BALKARIA: Nalchik, on the river Nalchik, 6.viii.1932, 3 ♀♀.

The similarity between the specimens studied and the description given by Klapálek is far from complete. The most obvious likeness is in the form of the subgenital plate (see fig. 2, *b*). The colouring of my specimens is lighter than that given by Klapálek, the general tone being yellow, with a patch of orange yellow between the ocelli. The pronotum is brownish yellow and the whole ventral surface of the head, thorax and abdomen is yellowish white, without any darker parts. This lighter colour may be explained by the teneral state of my specimens, but there are also some structural differences. The chief of these is that in my specimens the frontal tubercles are nearer to the posterior ocelli than to the compound eyes (fig. 2, *a*), whereas the opposite should be true according to Klapálek's description. The position of the ocelli in my specimens is slightly different (the relation of the distance between the posterior ocelli to the distance between each of them and the anterior ocellus is 1·14–1·23; the relation of the distance between the posterior ocelli to their distance from the compound eyes is 1·06–1·18), the pronotum is relatively broader (relation of length to breadth is 1·45), and the median field of same is relatively narrower ($\frac{1}{9}$ of total breadth of pronotum) than that given in Klapálek's description.

Length of body in my specimens: 16·5–18·0 mm.

Length of fore wing: 18·5–20·0 mm.

Whether the differences between my specimens and Klapálek's description are due to variation, to an inaccuracy of the description, or to a specific difference, I am not in a position to determine.

Isoperla Banks.

(*Chloroperla* Pictet.)

Several authors have recently stated that the determination of the species in the genus *Isoperla* (*Chloroperla*) presents exceptional difficulties (Bengtsson, 1933; Kühtreiber, 1934; Despax, 1936) and I have had the same experience in studying my material from the Caucasus. The difficulties are partly a result of the very considerable variation in the species belonging to this genus. In addition, however, the external genitalia, which in Plecoptera furnish the best specific characters, are not to be relied on in the genus *Isoperla* for the differentiation of the species. Kempny (1900), and after him Klapálek (1909) and Schoenemund (1924) considered the form of the female subgenital plate and the form of the chitinized lobe on the hind margin of the 8th sternite of the male to be reliable specific characters, but more recent authors have found these parts extremely variable. For my part I can confirm the opinion of Bengtsson and Despax, especially as to the variability of the form (relation of length to breadth) of the lobe of the 8th sternite.

A new specific character has been found by Despax in the structure of the interior sexual organs in the genus *Isoperla*, which, according to him, varies not only in different species, but in the subspecies of this genus. The part in question is the " penial sack," which is evaginated at copulation and has a typical chitinous armour on its surface. Different types of armour make it possible to subdivide the genus *Isoperla* into three groups of species. A longitudinal fold covered with special spines or scales (" Titillator " of Klapálek and auct.) is present on the surface of the penial sack in one group, to which *Isoperla grammatica* Scopoli, with a number of subspecies described by Despax, belongs. In other species the armour of the penial sack consists of a chitinized plate of variable form, which is covered with chitinous spicules or scales. Despax found this type in *I. rivulorum* Pictet, *I. strandi* Kempny, *I. viridinervis* E. Pictet, and in several species described by himself. In *Isoperla griseipennis* Pictet, Despax found neither a scaled fold, nor a scaled plate, but a group of very large single spines distributed on the wall of the penial sack so as to form a V-shaped figure.

After a superficial study of my material I was able to separate a smaller species which corresponded well with the description of *Isoperla rufescens* Stephens. Unfortunately, all the specimens of this species were females, so that the characters pertaining to the male could not be ascertained. All the other flies seem to belong to a group of nearly related species (two or perhaps even more species). None of these are identical with the known central European species, although the external characters would suggest an affinity to the *I. rivulorum*-*I. strandi* group. An investigation of the interior sexual organs of the males, however, showed the relations of the Caucasian flies to the central European species in a new light. In all the males in this group the penial sack is armed with a chitinized and scaled fold. Consequently they belong not to the *I. rivulorum*-*I. strandi* group, but to the *I. grammatica* group. On the other hand, the colouring of the Caucasian species differs very strongly from the colouring of *I. grammatica* ; they are much darker and the horse-shoe spot on the head is either indistinct, or complicated by other markings, or even lacking altogether. The lobe of the 8th sternite in the Caucasian species is of a lighter colour than the sternite itself, whereas in *I. grammatica* the opposite is usually true. The form of the chitinized fold on the wall of the penial sack in the Caucasian flies is entirely different from the form of the fold in *I. grammatica*, in which it is broadest posteriorly and gradually narrowed anteriorly. In the Caucasian species the fold is broadest anteriorly ; posteriorly it becomes narrower, but the edges in its posterior part turn outwards, so that the fold becomes more shallow (fig. 7). The Caucasian species are therefore distinct both from *I. grammatica* and its subspecies, and from the *I. rivulorum*-*I. strandi* group.

Isoperla rufescens Stephens.

KARACHAYEV LAND: Nevinnomysskaya, on river Kuban, 8.vii.1933, 1 ♀; Teberda, 1–17.viii.1933, 4 ♀♀. BALKARIA: Nalchik, on river Nalchik, 16.viii. 1939, 1 ♀.

The flies correspond well to Klapálek's description (1909). The relation of the distance between the posterior ocelli to the distance between each of these and the compound eye is 1·7–2·2 (Klapálek gives 22 : 10). In most of the flies the veins Sc, R and Rs are quite colourless almost as far as the radial cross vein. In the specimen from Nevinnomysskaya these veins are not quite colourless, but are of a lighter colour than the venation on the apex and the costa. This is exactly how Klapálek described the veins. The posterior margins of the abdominal tergites are distinctly darker than the tergites themselves.

Length of body: 8·5–9·5 mm. *Length of fore wing:* 9·5–11·0 mm. (Klapálek gives as wing span 20–22 mm., Schoenemund, 18–22 mm.)

As will be seen, *I. rufescens* inhabits the larger rivers on the northern slope of the Caucasian mountains.

Isoperla pulchra sp. n.

Antennae brown, proximally paler, but scapus dark brown. Head and pronotum vividly coloured in bright yellow and rust brown. General tone of head bright yellow; ocelli united by an approximately V-shaped brown stripe, but laterally this stripe is contiguous with other dark spots on head, and posterior ends approximate so as nearly to close in a central yellow spot (fig. 3, *b*). Lateral parts of M-line brown, as also frontal tubercles, so that general impression is of dark markings stretching transversely across head. Compound eyes connected by broad bright yellow band across vertex. Hindermost parts of head with an irregular striation. Relation of distance between posterior ocelli to distance of each of them to compound eye 1·2–1·9. Temples very convex. Ventral surface of head yellow, with indistinct brownish spots on submentum. Pronotum relatively broad (relation of breadth to length is 1·2–1·5), with approximately parallel and straight lateral edges and with sharp angles (fig. 4, *b*). Median field of pronotum yellow with a very fine brown or sometimes yellow median line. Breadth of median field in its narrowest part equal to $\frac{1}{5}$–$\frac{1}{6}$ of total breadth of pronotum. Lateral fields yellow with brown rugosities. Anterior and posterior submarginal lines likewise brown. Meso- and metanotum chestnut brown, but mesonotum with a yellow scutellum and anterior part of scutum. Sternites of thorax coffee-brown, other parts of ventral surface of thorax yellow. Legs rusty brown, femora dorsally and at knee, tibiae proximally darker. Wings delicate, hyaline of a slightly brownish shade. Venation fine, light brown. Sc on fore wings pale. Veins on hind wings all pale, only in apical part of wing brownish. Abdomen coffee-brown, in ventral surface yellowish brown. Tenth tergite obviously lighter coloured than the rest, yellow or at least with large yellow spots, produced in a triangle posteriorly. Cerci of uniform brown colour, darker than ventral surface of abdomen in male and in both sexes darker than 10th tergite (consequently 10th tergite contrasts by its light colour against both the other tergites and cerci).

Lobe of 8th sternite in male of a lighter colour than sternite; narrow, relation of breadth to length from tip to curve of chitin margin 1·6–2·6, to length from tip to bordering pigment line 1·0–1·6 (fig. 3, *a*). Subgenital plate in male approximately equal in length and breadth, with rounded posterior margin. Subanal plates usually bending over dorsal surface of abdomen. Penial sac with a chitinized and scaled fold; fold relatively broad (length 357–427 μ, breadth 80–115 μ). Chitinized edges of fold diverge posteriorly (fig. 4, *a*); span between their lateral margins being 127–217 μ. Scales relatively small (length 21–27 μ,

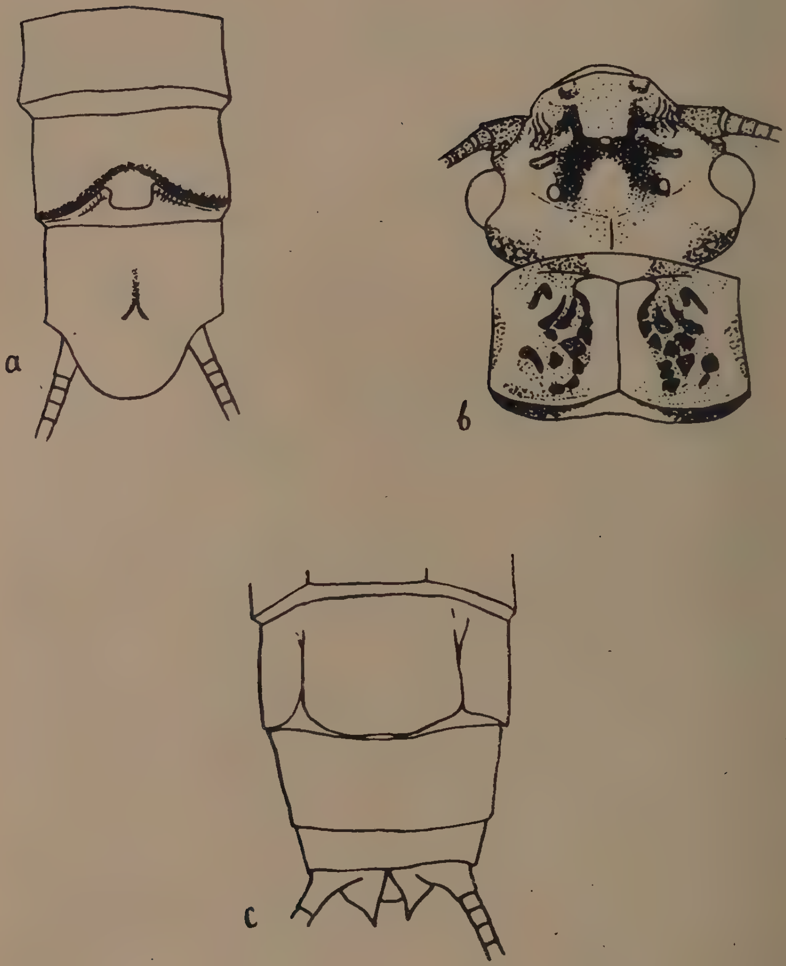

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FIG. 3.—*Isoperla pulchra* sp. n. *a*, Ventral view of abdomen of ♂; *b*, Head and prothorax; *c*, ventral view of abdomen of ♀.

breadth 7–9·5 μ), elongate-oval with heavily chitinized, produced and pointed free ends. Stalk of penial sac covered with scattered simple conical thorns.

Subgenital plate in female with simple semicircular posterior edge. Subanal plates broad, triangular with pointed ends (fig. 3, *c*). Tenth tergite produced posteriorly in a triangle.

Length of body, ♂, 9·5–11 mm. *Length of fore wing*, ♂, 10·0–10·5 mm.
Length of body, ♀, 12·5 mm. *Length of fore wing*, ♀, 12 mm.

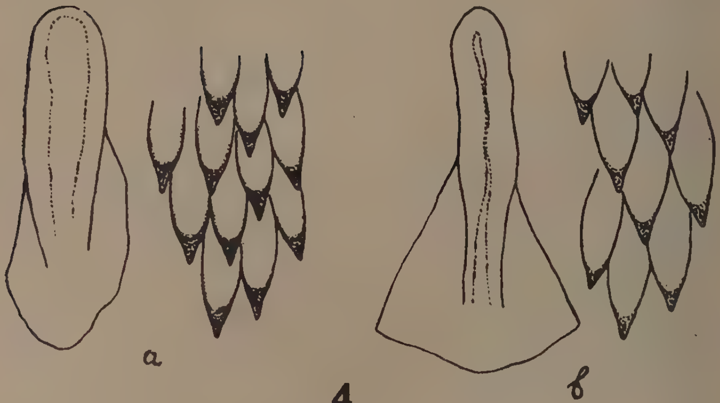
BALKARIA: Terskol stream, altitude near 2200 m., 20.vii.1932, 1 ♂, and 1 ♀. SVANETIA: Nakra valley, zone of shrubs (above the forest zone), 30.vii.1932, 6 ♂♂.

The presence of a chitinized and scaled fold in the penial sack places *I. pulchra* in the *I. grammatica* Scopoli group. On the other hand, the form of the fold and its scales is entirely different from that found in *I. grammatica*. The differences in coloration between *I. pulchra* and *I. grammatica* are such that it is quite impossible to confuse these two species. As Despax has pointed out (*loc. cit.*), *I. virens* Zetterstedt probably belongs also to the *I. grammatica* group. The penial sack in this species has not yet been studied in detail, but in a drawing of *I. virens*, Bengtsson (1933) has figured the penial fold as it is seen in an intact insect owing to the transparency of the chitin cuticle; one can clearly see a longitudinal line in the corresponding place in Bengtsson's drawing. I will therefore stress some features of *I. pulchra* which distinguish it from *I. virens*. According to the redescription of the latter species by Bengtsson, the distance between the posterior ocelli in *I. virens* is equal to or only slightly greater than their distance from the compound eyes, whereas in *I. pulchra* the ocelli stand wide apart and are approximated to the compound eyes. The subgenital plate in the female of *I. virens* covers half of the length of the 9th sternite (cf. fig. 19 of Bengtsson), whereas in *I. pulchra* it only just projects beyond the posterior margin of the 8th sternite. The pronotum in *I. virens* has a " fine and sharp black margin "; there is no such margin in the species described here.

The localities where it was found show *I. pulchra* to be the most highly alpine form of all the Caucasian *Isoperla* species. The other species of this genus were collected in lower regions.

Isoperla caucasica sp. n.

Antennae dark brown, proximally lighter, scapus dark brown. Head of a pale yellow or light brown general colour with dull brown, somewhat indistinct markings. In middle part of frons a large dark field connecting ocelli and leaving a yellow frontal spot in the centre. In teneral flies ring round frontal spot interrupted posteriorly and in very dark specimens frontal spot is not yellow, but only of a lighter brown than the surrounding field. Dark field is continued anteriorly by dark markings, which reach to clypeus. M-line not very distinct, especially in its lateral parts, so that dark markings on the head appear to be elongated in a longitudinal direction (fig. 5, *b*). Relation of distance between posterior ocelli to distance between each of those and the compound eye is 1·1–2·1. Compound eyes connected across vertex by a yellow or light brown band with indistinct margins. Ventral surface of head whitish, yellowish or light brown with an indistinct dark spot on submentum. Pronotum rather broad (relation of breadth to length 1·2–1·6, mostly 1·3–1·4), with approximately parallel sides. Lateral margins usually straight and angles sharp, but in some specimens anterior angles quite distinctly rounded. Median field pale yellow or light brown, with a fine brown median line. Breadth of median field in narrowest



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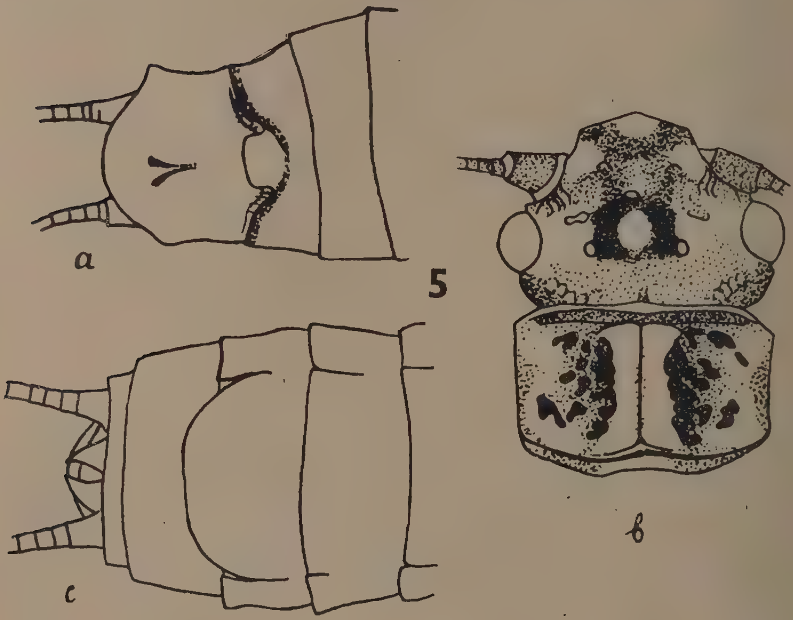

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Figs. 4-5.—(4) The scaled fold of the penial sac with details of scales (highly magnified) of two Caucasian *Isoperla* species. *a*, *I. pulchra* sp. n.; *b*, *I. caucasica* sp. n. Both drawn to the same scale. (5) *Isoperla caucasica* sp. n. *a*, Ventral view of abdomen of the ♂; *b*, head and prothorax; *c*, ventral view of abdomen of the ♀.

part equal to $\frac{1}{5}$–$\frac{1}{6}$ of total breadth of pronotum. Lateral fields brown, with dark brown rugosities. Meso- and metanotum dark brown. Mesonotum with yellow scutellum and anterior part of scutum, but in some very dark specimens scutum of mesonotum uniformly brown and scutellum only of slightly lighter colour. Ventral surface of thorax pale yellow or light brown with dark sclerites. Legs brown, proximal parts of tibiae and longitudinal stripes on dorsal surface of femora darker. Occasionally dark brown lines on sides of femora. Wings vary in colour from ashen gray to olive brown or greenish gray. Venation brown and rather coarse. Sc usually paler than other veins or even quite unpigmented. Venation on hind wings of same colouring as on fore wings, though somewhat paler. Abdomen in males all brown, in females dorsal surface brown, ventral surface pale yellow. The 10th tergite usually not different in colour from other tergites. Cerci thick, rather short, reaching only to ends of wings or just a little beyond them. Colour of cerci varies from light brown to almost brownish black; proximally quite distinctly darker in some specimens.

Lobe of 8th sternite in male lighter coloured than sternite; its breadth varies considerably. Relation of breadth to length from tip to curvature of chitinized margin 1·7–3·7, relation of breadth to length from tip to bordering pigment line 0·9–1·5 (fig. 5, *a*). Subgenital plate in male approximately equal in length and breadth and with a rounded posterior margin. Subanal plates (in specimens which I have studied) not folded on to dorsal surface of abdomen. Penial sac with a chitinized and scaled fold. Length of fold 406–490 μ; breadth 56–112 μ. Edges of chitinized plate forming the fold spread out laterally at posterior end (fig. 4, *b*), span between lateral margins being 161–210 μ. Scales larger than in *I. pulchra* (length 27–36 μ, breadth 8·5–11 μ), elongate oval, with heavily chitinized, produced and pointed ends. Stalk of penial sac covered with scattered simple conical spines.

Subgenital plate of female (fig. 5, *c*) broad and large, generally rounded posteriorly, but in some specimens truncate or even slightly emarginated in the middle; it covers from $\frac{1}{4}$ to nearly $\frac{1}{2}$ of length of 9th sternite. Tenth tergite produced posteriorly in a triangle tip may be pointed or rounded. Subanal plates broad, triangular.

Length of body, ♂, 9·5–11·5 mm. *Length of fore wing*, ♂, 10·0–12·0 mm.

Length of body, ♀, 12·0–14·0 mm. *Length of fore wing*, ♀, 11·5–13·5 mm.

Types: Karachayev Land: Resort Teberda, 20.vii.1933, 2 ♂♂, 1 ♀.

Other specimens: Karachayev Land: Stream Gedeij in the Teberda valley above the resort Tebarda, 30.vii.1933, 2 ♂♂, 5 ♀♀; River Amanaus, 20.vii.1933, 1 ♂. Balkaria: River Sokoshili-Su, 17.vii.1932, 3 ♀♀; Adyr-Su valley, near upper border of the forest zone, 3–11.viii.1939, 2 ♂♂, 7 ♀♀.

This species is extremely variable not only in coloration, but also in structural characters, the divergent features being found almost at random in single specimens, so that it appears impossible to subdivide the species into smaller and more definitely characterized groups, at least on the basis of the material which was at my disposal. In treating them as a single new species I have been guided by the structure of the penial sac. The presence of a chitinized and scaled fold places *I. caucasica* in the *I. grammatica* Scopoli group. From the latter species *I. caucasica* differs very considerably in the form of the fold and of its scales, besides differing very markedly in coloration. The distinctions from *I. virens* are the same as in *I. pulchra* (except the subgenital plate of the female). *I. caucasica* differs from *I. pulchra* in having distinctly larger scales on the penial fold, as well as in the coloration of the wings, head, 10th tergite, and cerci.

Chloroperla Newman.

(*Isopteryx* Pictet).

I have found in the Caucasus two species of the genus *Chloroperla*, both of which seem to be new.

Chloroperla katherinae sp. n.

Antennae appear slightly serrate owing to distal thickening of segments (fig. 6, *d*); proximally yellow, distally darkened, distal ½ to ⅔ brown. Head yellow without any markings. Pronotum yellow, with thin black (dark brown in specimens preserved in alcohol) median line and still thinner anterior and posterior submarginal lines (fig. 6, *b*); no black margin laterally. The pigmented pleurae may be seen through lateral parts of pronotum in the form of dark marks. Scutellum of mesonotum and metanotum with black margin and median line. Legs yellow with brown tarsus. Wings yellow with fine yellow veins. In area between Cu1 and Cu2 are 3–6 (usually 4–5) cross veins. Abdomen yellow, with broad dark brown longitudinal band on the 1st–7th (more rarely on 1st–8th) tergites. Cerci short, hardly longer than ½ of abdomen, uniformly yellow (only the tip of last joint scarcely perceptibly darker).

Subgenital plate of male produced at the end in a blunt tip. Supra-anal hook in male bent anteriorly at right angles and tip produced in a ventrally directed sharp claw (fig. 8, *a*). Subgenital plate of female subdivided posteriorly by a deep incision into two rounded lobes (fig. 6, *c*).

Length of body, ♂, 9 mm. *Length of fore wing*, ♂, 10 mm.

Length of body, ♀, 9·5–11·0 mm. *Length of fore wing*, ♀, 12·0–12·5 mm.

BALKARIA: Djilki-Su valley, 15.vii.1932, 1 ♂, 6 ♀♀. SVANETIA: Nakra valley, 28.vii.1932, 2 ♀♀. KARACHAYEV LAND: Stream Baduk, 11.vii.1933, 1 ♂, 2 ♀♀.

This species is easily recognized by its large size, distinct black median line and absence of black margins on the pronotum, and by the form of the supra-anal hook. It inhabits the larger rapidly flowing streams near the upper margin of the forest zone. I name this species in honour of my wife, Katherina Balinsky-Syngajewskaja, who has always accompanied me on my collecting excursions to the Caucasus.

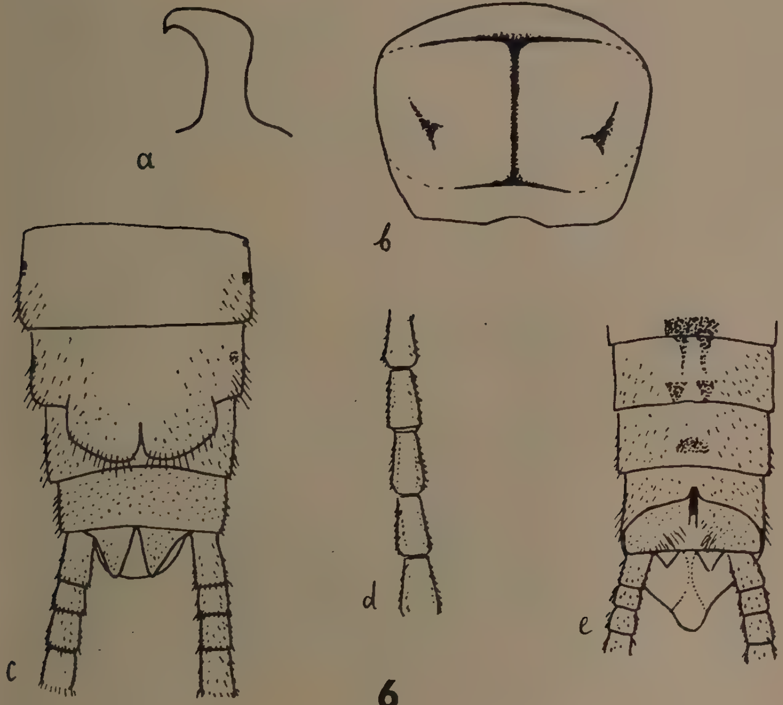
Chloroperla teberdinica sp. n.

Form of segments in antennae similar to that in the previous species; owing to a thickening of distal ends of segments, antennae appear slightly serrate (fig. 7, *b*). Colouring of antennae: proximal ¼ yellow, distal ¾ black. Head pale yellow, only space between ocelli brownish (not even an indistinct V-shaped spot). Pronotum pale yellow with brown median band and a still darker narrow median line. Anterior submarginal lines continued by black lines running along lateral edges of pronotum. Posterior submarginal line short and does not reach sides of pronotum (fig. 7, *a*). Scutellum of mesonotum and metanotum with black margin and median line. Legs pale yellow, tarsus black. Wings yellow with very fine yellow veins. In area between Cu1 and Cu2 there are 3–5 cross-veins. Abdomen pale yellow with broad dark brown longitudinal band on tergites 1–8 (as an exception only on tergites 1–7). Cerci short, little longer than ½ of abdomen, yellow, only tip of last joint brownish.

Male unknown.

Subgenital plate of female covered with long hairs, subdivided into two rounded lobes by a small incision on its posterior edge. Depth of incision varies considerably, in some specimens almost imperceptible. Fig. 7, *c* and *d*, shows the extreme variation in development of the incision.

Length of body, ♀, 6–7 mm. *Length of fore wing*, 7–9 mm.



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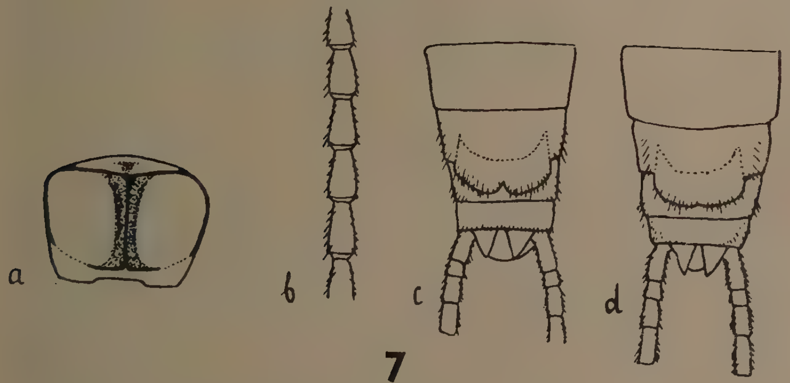

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Figs. 6–7.—(6) *Chloroperla katherinae* sp. n. *a*, Supra-anal hook of ♂ ; *b*, pronotum ; *c*, ventral view of abdomen in the ♀ ; *d*, part of the antenna ; *e*, dorsal view of the abdomen of the ♂. (7) *Chloroperla teberdinica* sp. n. *a*, Pronotum ; *b*, part of the antenna ; *c* and *d*, ventral views of the female abdomen, showing extreme variations in the expression of posterior incision on the subgenital plate.

KARACHAYEV LAND: Teberda Valley, in the vicinity of the resort Teberda, mostly on the River Teberda, 10–17.vii.1933, 46 ♀♀.

This species bears some similarity to *C. burmeisteri* Pictet. It differs in having a pale yellow instead of greenish yellow colouring, by the absence of the V-shaped spot in the region of the ocelli, by the presence of a broad brown median band besides the black median line on the pronotum,[1] by the absence of dark rings on the cerci and by the shortness of the same. It inhabits the River Teberda.

The two species here described may be very easily distinguished from each other by the following characters.

Table for Distinguishing the Caucasian Species of the Genus Chloroperla.

	Chloroperla katherinae sp. n.	*Chloroperla teberdinica* sp. n.
Dimensions .	Large, length of fore wing of ♂ 10 mm., of ♀ 12–12·5 mm.	Smaller, length of fore wing (♀) 7–9 mm.
General colour .	Yellow.	Pale yellow.
Antennae . .	Gradually darkened distally, last ½ to ⅔ brown.	Distally abruptly darkened, distal ¾ black.
Head . .	Without any markings.	With a brownish tone between the ocelli.
Pronotum .	Without a black line on the lateral margin, only a median black line present.	With black margin laterally, besides the black median line there is a broad brown median band.[1]
Subgenital plate of ♀	Posteriorly with a deep incision.	Posteriorly with a small, not always distinct incision.

Leuctra Klapálek.

Martynov enumerates five species of the genus *Leuctra* as being found in the Caucasus. Of these four have been described by him as new. In my collection I found four of the species mentioned by Martynov, and besides these two more new species.

Leuctra furcatella Martynov.

This species may be recognized by the following characters.

Head and antennae dark brown. Antero-medially of each compound eye lies a small dark spot surrounded by a rather broad pale margin. Length of pronotum greater than breadth. Legs dark brown, femora darker at distal ends. No longitudinal stripes on femora. Wings hyaline, but with a distinct brownish tone. Venation light brown. In the male 1st–7th tergites of normal structure. The median chitinized part of 8th tergite very much protruded caudad and connected with lateral chitinized parts by long chitin rods, which diverge anteriorly (fig. 8, *a*). Between these rods there is a large weakly chitinized field. Middle part of 8th tergite emarginated posteriorly, so that lateral angles protrude in form of two short horns. Vesicle of the 9th sternite long and rather narrow (fig. 8, *b*), its base very near anterior margin of sternite. Subanal plates produced in long and narrow processes, which bend dorsally parallel to titillators, but are somewhat shorter than the latter. Supra-anal process broad, on its surface lie two chitin stripes which converge and fuse anteriorly (fig. 8, *c*).

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[1] It must be noted that the broad brown band on the pronotum varies considerably in its development; in some specimens it is just perceptible. On the other hand, the dark shade in the region between the ocelli is almost entirely lacking in some specimens; in none of the specimens studied did this marking even distantly resemble a V-shaped spot.

Length of body, ♂, 6·5 mm. *Length of fore wing*, 7 mm.

Balkaria : Stream Terskol, altitude about 2200 metres, 20.vii.1932, 3 ♂♂.

This species may be easily distinguished by the structure of the 8th tergite. There is some resemblance only to *L. alpina* Kühtreiber (1934), but in the Caucasian species the middle part of the 8th sternite protrudes caudad more than in the alpine species. The supra-anal process is broad in *L. furcatella*, whereas in *L. alpina* it has a narrow stalk. The specimens which I studied agree fairly well with Martynov's description and figures, but there are some minor differences. According to Martynov the length of the pronotum exceeds its breadth by one-quarter. In my specimens the relation of length to breadth of pronotum is 16·5 : 14·5 ; 17·7 : 16 ; 18 : 16. The number of cross veins in the area between M and Cu1 is, according to Martynov, 6–7, the number of cross veins between Cu1 and Cu2,12. In my specimens the number of cross veins is somewhat smaller : 3–5 and 8–11 respectively.

Leuctra dispinata sp. n.

Antennae dark brown, somewhat paler proximally. Head brown, antero-medially from each compound eye a distinct black spot, which in some specimens is surrounded by a narrow pale margin. Pronotum with converging anteriorly slightly rounded sides. Length and breadth of pronotum approximately equal, in some specimens the length, in others the breadth is slightly greater. Anterior and posterior submarginal lines on pronotum black, anterior submarginal line especially strong. Lines bordering the median field converge gradually caudad, and turn laterally rather sharply in their posterior $\frac{1}{3}$ or $\frac{1}{4}$. Sculpture on lateral fields of pronotum well developed but differs but slightly in its darker colour. Legs brown. No longitudinal stripe on femur. Wings pale with light brown veins. Abdomen in male dark brown, in female ventral surface dark brown, dorsal surface light brown.

In the male 1st–7th tergites normal in structure. Chitinized lateral parts of 8th tergite narrowed dorsally where they are united by a dark strongly chitinized plate, which is produced posteriorly in two short horns (fig. 9, *a*), between which there is a rectangular incision. Vesicle of 9th sternite very short and broad, its base removed from anterior margin of 9th sternite by a distance approximately equal to length of vesicle (fig. 9, *b*). Subanal plates produced in long, narrow, slightly curved and pointed processes. Titillators absent. Cerci rather slender, on their dorsal surface rather narrow chitinized stripes. Supra-anal process rather narrow, with two chinitized stripes on its sides, which converge anteriorly but do not unite (fig. 9. *c*).

Subgenital plate of female broad and rather short (fig. 9, *d*), scarcely reaching beyond posterior edge of 8th sternite, posteriorly rounded and slightly emarginated in middle of posterior circumference. Subanal plates broad, rounded, concave laterally. Cerci short, cylindrical.

Length of body, ♂, 4·5–5·5 mm. *Length of fore wing*, ♂, 5·5–6·0 mm.
Length of body, ♀, 5·5–7·0 mm. *Length of fore wing*, ♀, 7–8 mm.

Balkaria : Stream Djilki-Su, 15.vii.1932, 9 ♂♂ and many ♀♀ ; Stream Sokoshili-Su, 17.vii.1932, 1 ♀.

This species is especially characterized by the absence of the titillators. The form of the 8th tergite, the very short and broad vesicle of the 8th sternite in the male, and the form of the subgenital plate in the female serve further to distinguish it from the known species.

Leuctra balcarica sp. n.

Antennae dark brown. Head brown with dark spots as in *L. dispinata* sp. n. Pronotum and legs as in *L. dispinata.* Wings quite pale with light brown venation. Abdomen of male dark brown, in female ventral surface dark brown, dorsal surface light brown.

Tergites 1–7 in male of a normal structure. Chitinized lateral parts of 8th tergite narrowed dorsally, where they are united by a dense black strongly chitinized plate. Plate produced posteriorly in two short horns lying closely to one another (fig. 10, *a*). Vesicle of 9th sternite very short and broad, its base removed from anterior margin of 9th sternite by a distance approximately equal to length of vesicle (fig. 10, *b*). Posterior margin of 9th sternite slightly curved. Subanal plates produced in long, narrow, slightly curved and pointed processes. Titillators absent. Cerci somewhat thicker than in *L. dispinata* and with a broader chitinized stripe on their dorsal surface. Supra-anal process as in *L. dispinata,* but somewhat narrower.

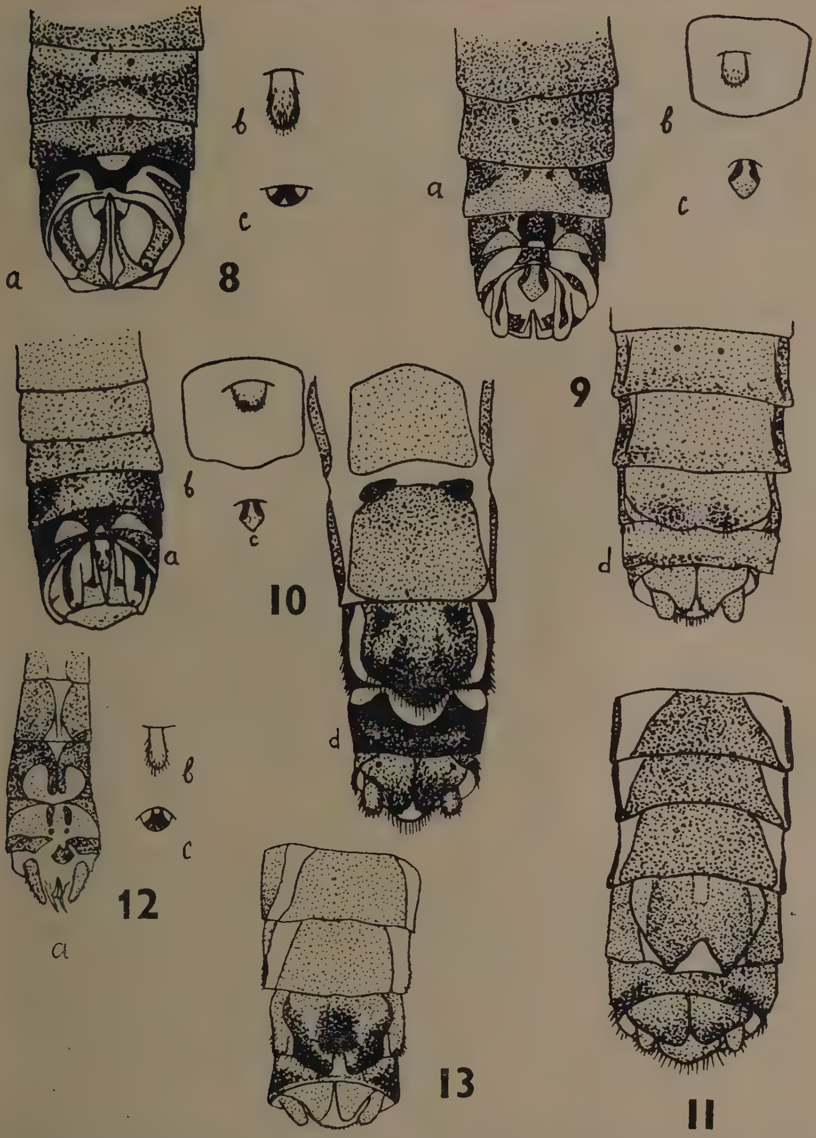
Subgenital plate of female broad and rather short (fig. 10, *d*), scarcely reaching beyond posterior edge of 8th sternite, posteriorly evenly rounded or with slightly produced median part. The produced median part of subgenital plate also slightly convex ventrally. Subanal plates and cerci as in *L. dispinata.*

Length of body, ♂, 4–5 mm. *Length of fore wing,* ♂, 5·5–6 mm.
Length of body, ♀, 5–7·5 mm. *Length of fore wing,* ♀, 6·5–8 mm.

SVANETIA: Nakra valley, 30.vii.1932, 1 ♂. BALKARIA: Adyr-Su valley, 3–11.viii.1939, 3 ♂♂ and many ♀♀.

This species is doubtlessly very closely related to *L. dispinata.* Both have in common the absence of the titillators, but there are also other considerable differences, the most important of which are the structure of the 8th tergite in the male and the form of the subgenital plate in the female. Minor differences are present in the colouring and in the structure of the cerci. *L. balcarica* is usually somewhat smaller than *L. dispinata.*

On the other hand, the structure of the 8th sternite of the male in *L. balcarica* is very similar to that of *L. tarnogradskii* Martynov. Most of the characters which Martynov describes as distinguishing *L. tarnogradskii* are found also in *L. balcarica*, but the characters in question are so general that they can scarcely serve to identify a species with certainty. The precise relationship of the two species depends chiefly on whether or not the males of *L. tarnogradskii* possess titillators. According to Martynov, *L. tarnogradskii* should have titillators. The description runs: "Subanal plates and titillators rather long, slightly curved" (l.c., p. 38). In contradiction to this description the titillators are lacking in the drawing given by Martynov (Plate VI, fig. 1 and 2). Both in the profile drawing and in the dorsal aspect, only one pair of long processes is shown at the posterior extremity of the abdomen of the male, whereas in the other drawings, showing males of other *Leuctra* species, two pairs of processes are depicted quite distinctly. It seems, therefore, that Martynov failed to notice the absence of the titillators (in spite of the fact that he made a correct drawing!). If Martynov's figure and not his text were correct, an important difference between his specimens and those studied by myself would prove to be non-existant. A further difference between *L. tarnogradskii* and *L. balcarica* is indicated, presumably, by the structure of the genitalia in the female. The form of the subgenital plate in both species is



FIGS. 8–13.—(8) *Leuctra furcatella* Martynov. *a,* Dorsal view of the abdomen of ♂; *b,* vesicle of the 9th sternite; *c,* supra-anal process. (9) *L. dispinata* sp. n. *a,* Dorsal view of the abdomen of the ♂; *b,* 9th sternite of ♂ with vesicle; *c,* supra-anal process; *d,* ventral view of the abdomen of the ♀. (10) *L. balcarica* sp. n. *a,* Dorsal view of the abdomen of the ♂; *b,* 9th sternite of ♂ with vesicle; *c,* supra-anal process; *d,* ventral view of the abdomen of the ♀. (11) *L. uncinata* Martynov. Abdomen of the ♀, ventral view. (12) *L. collaris* Martynov. *a,* Dorsal view of the abdomen of the ♂; *b,* vesicle of the 9th sternite; *c,* supra-anal lobe of the ♂. (13) *L. fusciventris* Stephens. Abdomen of the ♀, ventral view.

certainly very similar, but Martynov claims to have seen a pair of narrow vaginal plates behind the subgenital plate in *L. tarnogradskii*. Such vaginal plates are very definitely absent in *L. balcarica*. If Martynov's observations are correct we should have here a clear distinction between the females of *L. tarnogradskii* and *L. balcarica*. On this point also, as in the case of the titillators in *L. tarnogradskii*, a definite solution could quickly be reached by investigating Martynov's types. This way of solving the problem is impossible for me at present as Martynov's types have been kept in the Zoological Museum of the Academy of Sciences in Leningrad.

Leuctra uncinata Martynov.

Antennae brown, towards the end almost black. Head dark chestnut brown. Pronotum chestnut brown, somewhat lighter than head. Length and breadth of pronotum nearly equal (measured in divisions of the eye-piece micrometer 17/18 and 16/15·5 ; according to Martynov length somewhat greater than breadth). Legs light brown with very distinct longitudinal stripes on femora ; on each femur a longitudinal stripe on the side and a short longitudinal stripe on dorsal surface proximally. Distal end of tibia and tarsus darker. Wings very pale, hyaline. Veins on hind wings almost entirely yellow, brownish only at apex. Veins in proximal parts of fore wings yellow, in distal parts light brown. Abdomen (female) chestnut brown ventrally and of a light reddish brown colour dorsally.

Subgenital plate of female produced posteriorly in two approximately triangular chitinized processes between which is stretched a pale membrane (fig. 11). On proximal part of subgenital plate an oblong pale spot. Subanal plates short and broad, cerci very small.

Length of body, ♀, 6–6·5 mm. *Length of fore wing*, 7–8 mm.

Svanetia : Nakra valley, 28–29. vii. 1932, 2 ♀♀.

The peculiarities of colouring in the legs and wings are not given in Martynov's description. The structure of the subgenital plate confirms beyond doubt the identification of my specimens.

Leuctra collaris Martynov.

Antennae of a uniform brown colour. Head brownish yellow. Irregular and indistinct brown lines on occiput. Pronotum brownish yellow with poorly visible pattern. Lateral margins straight, converging somewhat craniad. Length and breadth of pronotum approximately equal. Legs brownish yellow. Wings pale and hyaline with very pale brownish venation. Abdomen (in male) brownish yellow.

Sixth tergite in male normal ; 7th tergite membranous in its mid-dorsal part, but without any chitinized processes. Eighth tergite membranous mid-dorsally. Lateral chitinized parts produced on their median ends in two chitinized rod-like processes which run caudad parallel to one another but are not fused (fig. 12, *a*). Ends of these processes rounded. Membranous 9th tergite bears on its surface two longitudinal dark chitinized lines, and posteriorly to those two dark dots. Vesicle of 9th sternite long and narrow (fig. 12, *b*), its base attached at anterior margin of sternite. Processes of subanal plates and titillators long and very much curved dorsally ; the former a little shorter than the latter. Cerci long and narrow. Supra-anal process broad, rounded posteriorly. Nearly all of the dorsal surface chitinized (one single piece of chitin instead of a paired piece as in many other species (fig. 12, *c*)).

Length of body, ♂, 5.5–6 mm. *Length of fore wing*, 6.5 mm.

Karachayev Land : River Teberda, above the resort Teberda, 11. vii. 1933, 3 ♂♂.

The similarity between my specimens and the description given by Martynov is not very complete. According to Martynov the length of the pronotum is one-quarter greater than the breadth. The pronotum in my specimens looks oblong at the first glance, but measurement shows length and breadth to be equal. The results of the measurements (length/breadth in divisions of the eye-piece micrometer) are: 12/12, 12/12, 12/11·5. The number of cross veins in the area between M and Cu1 is, according to Martynov, 5–7, in the area between Cu_1 and Cu_2: 12–13. In my specimens the number of of cross veins is 3–5 and 9–12 respectively. The structure of the posterior segments of the abdomen in the male agrees rather well with Martynov's description, except that he does not mention the dark dots on the 9th tergite.

Leuctra fusciventris Stephens.

(*Leuctra klapáleki* Kempny.)

BALKARIA: Stream Djilki-Su, 15.vii.1932, 2 ♀♀. KARACHAYEV LAND: Teberda valley, Stream Chotipara, 12.vii.1933, 1 ♀.

The correctness of the identification of this species is supported by the fact that Martynov also found *L. fusciventris* to occur in the Caucasus. The females studied, although bearing a general resemblance to Central European specimens of the same species, differ from them in some respects. In the Caucasian specimens the median part of the subgenital plate is markedly convex and is covered with long hairs (fig. 13). In Central European specimens (I studied a large number of females of this species from South Germany) the median part of the subgenital plate is not convex; on the contrary, the lateral parts (lobes) protrude above the surface of the medial part. Also there are no conspicuous hairs on the median part of the subgenital plate. The number of cross veins between M and Cu_1 and between Cu_1 and Cu_2 is, in the Caucasian specimens, smaller than in specimens from Central Europe. The respective numbers given in Kempny's description are 5 and 11–14, the numbers which I found in the population from South Germany are 6–8 and 11–16, the numbers found in the Caucasian specimens are 3–5 and 7–11. The specimens from the Caucasus (6·5–7·0 mm.) are also smaller than those from South Germany (7·5–10·0 mm.).

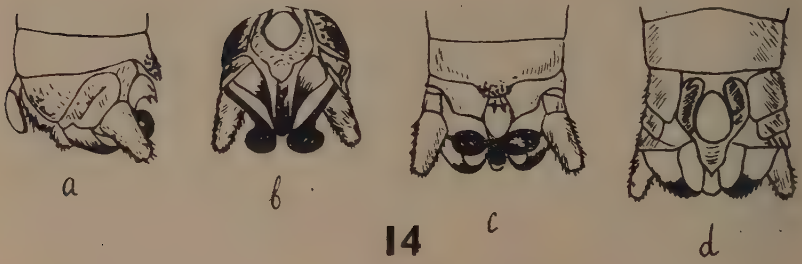
Protonemura Kempny.

The genus (or subgenus) *Protonemura* is represented in the Caucasus by a large number of species, all of which seem to be endemic.

Protonemura medialis sp. n.

Antennae uniformly dark brown. Head black. Pronotum chestnut brown, glossy, narrower posteriorly, with straight sides but with rounded anterior angles. Mesonotum darker than pronotum. Legs light brown, Femora with dark brown distal ends, especially in the third pair of legs, with dark longitudinal stripes on sides, and with a short dark stripe dorsally on proximal part. Tarsus of a uniform dark brown. Wings hyaline, with thin but dark veins. Region of the X-like figure and the pterostigma distinctly darkened.

Vesicle of 9th sternite in male especially broad, ovoid (fig. 14). Process of 9th sternite relatively short. Subanal plates triangular, apex narrowed gradually and produced in a pointed strongly chitinized rod. Rods point caudad and dorsad and come to lie on both sides of supra-anal lobe. Points of rods do not reach to ends of intermediate processes. The latter soft and pale on medial surface, strongly chitinized on exterior surface, and



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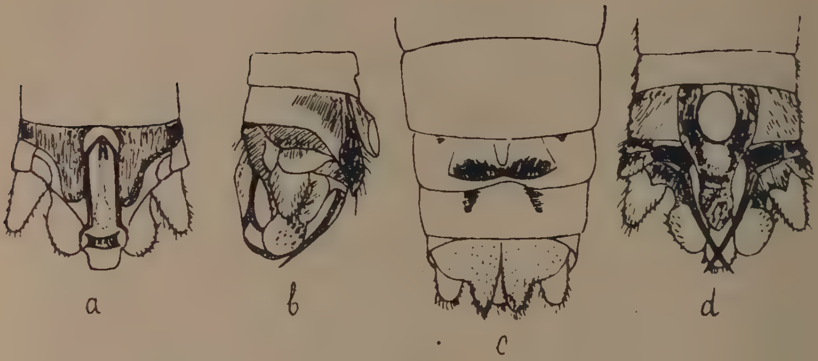

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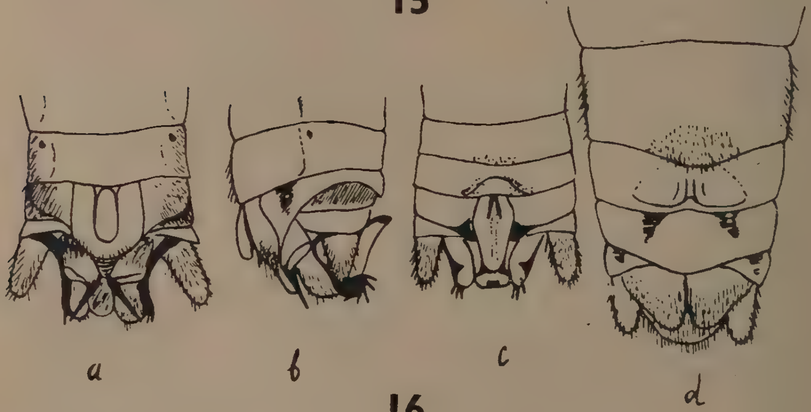

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FIGS. 14–16.—(14) *Protonemura medialis* sp. n. ♂. End of abdomen in lateral (*a*), caudal (*b*), dorsal (*c*) and ventral (*d*) view. (15) *Protonemura gladifera* sp. n. *a*, Abdomen of ♂, dorsal view; *b*, abdomen of ♂, lateral view; *c*, abdomen of ♀, ventral view; *d*, abdomen of ♂, ventral view. (16) *Protonemura viridis* sp. n. *a, b, c,* Abdomen of ♂ in ventral, lateral and dorsal view respectively; *d*, abdomen of ♀ in ventral view.

forming distally strongly chitinized club-like swelling, which is nearly round, though slightly broader transversely. This swelling without teeth, spines or strong bristles. Supra-anal lobe relatively short, compressed laterally, and bearing towards the end, on its outward (morphologically ventral) surface, a transverse incision with two small teeth pointing caudad on distal margin of incision. Eighth tergite bears on its posterior margin a prominence which protrudes over 9th tergite and is covered with small short spines. Cerci moderately long, conical.

Female unknown.

Length of fore wing 8 mm.

Karachayev Land: River Amanaus, Dombai valley, 20.vii.1933, 1 ♂.

This species somewhat resembles *Protonemura lateralis* Pictet, but differs from the latter by the chitinized rods of the subanal plates being directed caudally instead of laterally, by the swelling on the end of the intermediate process which lacks any spines, and by the peculiar prominence on the posterior margin of the 8th tergite.

Protonemura gladifera sp. n.

Antennae uniformly brown. Head dark chestnut brown. Pronotum with straight sides but with rounded anterior angles, narrower posteriorly. Pronotum chestnut brown with a darker pattern. Legs light brown, femora somewhat darker at distal ends. Tarsus dark brown. Wings brownish, in fully coloured specimens shaded, especially in the pterostigma region. Venation brown. Abdomen reddish-brown.

♂ (fig. 15, *a*, *b*, *d*): Vesicle of 9th sternite very broad, oval or slightly ovoid. Process of 9th sternite long and broad. Sub-anal plates distinctly subdivided into a basal plate and a long chitinized rod attached to plate posteriorly. Basal plate very short (relation of length to breadth is as 1 : 2). Rods in form of sabres, only slightly curved, directed caudad, and in some specimens crossed under supra-anal lobe. Rods longer than intermediate processes, which are more strongly chitinized on their latero-ventral surface and end distally in moderately chitinized club-like swellings. Latero-ventral surface of these swellings bears a group of black spines, pointing cranio ventrally. Supra anal lobe long and narrow; on its distal end it bears two small chitinized longitudinal lines. Cerci relatively short.

♀ (fig. 15, *c*): Seventh sternite normal; 8th sternite modified to form a subgenital plate, which has no distinct margin anteriorly and laterally. Posterior margin bears two lateral more strongly chitinized outgrowths, subdivided from one another medially by a shallow notch. In fully coloured specimens outgrowths are distinguished by a darker chestnut brown pigmentation. Subanal plates very characteristic; their medial margin produced posteriorly in a pointed process.

Length of fore wing, ♂, 7–8 mm.

Length of fore wing, ♀, 7·5–8·5 mm.

Svanetia: Nakra valley, 30.vii.1932, 1 ♀. Karachayev Land: Stream Chadjibei, altitude about 2000 m., 16.vii.1933, 6 ♂♂ and 8 ♀♀. Both localities are on the upper margin of the zone of shrubs.

This species bears some resemblance to *Protonemura nimborum* Ris, but differs from the latter in a number of features. In the male the basal plate of the subanal plates is much shorter than in *P. nimborum*, the rods do not diverge laterally, and the intermediate processes have a different form. In the female the produced ends of the subanal plates are longer and situated more medially than in *P. nimborum*.

Protonemura viridis sp. n.

Antennae brown, distally darker. Head brown anteriorly, frons and occiput green, with brownish spots on latter. Pronotum green with brownish spots on lateral fields, with straight sides and somewhat rounded anterior angles, narrowed posteriorly. Meso- and metanotum brown. Legs green with brown longitudinal stripes on sides of femur and on dorsal surface at proximal end of same. Wings green with brownish-green venation.

♂ (fig. 16, *a*, *b*, *c*): Vesicle of 9th sternite elongate oval, rather narrow. Subanal plates subdivided into a basal plate and a pointed rod, connected to postero-medial angle of this plate. Rod points postero-laterally. Intermediate processes with strongly chitinized lateral margin which is curved dorsad and ends in a strongly chitinized swelling, which bears several powerful spines. Supra-anal lobe long, broadened distally. On its outer (morphologically ventral) surface, before the end, it bears two chitinized short lines, which converge distally. Cerci moderately long, conical.

♀ (fig. 16, *d*): Posterior margin of 7th sternite somewhat projecting and densely covered with small bristles. Eighth sternite bears subgenital plate of approximately triangular form, with base of triangle lying posteriorly. A notch in middle of posterior margin and a furrow running along middle of plate, thus subdividing it in two lateral parts. Subanal plates very blunt, of simple triangular form.

Length of fore wing, ♂, 8 mm.
Length of fore wing, ♀, 9 mm.

SVANETIA: A stream in the Nakra valley, 28.vii.1932, 1 ♂; River Nakra, 29.vii.1932, 1 ♂ and 1 ♀. KARACHAYEV LAND: River Amanaus, near the Amanaus glacier, 24.vii.1933, 1 ♂.

This species is clearly distinguished from other Nemourids by its green colour.

Protonemura triangulata Martynov.

BALKARIA: in the village of Verchniy Baksan, 15.viii.1939, 3 ♂♂.
The specimens correspond well with Martynov's description.

Protonemura breviuscula Martynov.

BALKARIA: In Adyr-Su valley, 11.viii.1939, 1 ♂.
The specimen corresponds fairly well with Martynov's description.

Protonemura falciformis Martynov.

BALKARIA: Near Stream Terskol, 20.vii.1932, 1 ♂.

The specimen corresponds in general with Martynov's description, but there are several minor differences: (1) The chitin rod of the subanal plate is somewhat longer than figured by Martynov and is not simply pointed, but bears a jag before the end on its concave side. (2) The chitin rods are connected, not with the hindermost point of the basal part of the subgenital plate, but with the medio-caudal angle of this plate (fig. 17). (3) The posterior process of the 9th sternite is longer and broader than figured by Martynov. (4) Short black spines are present on the 7th tergite as well as on the 8th and 9th tergite.

Length of fore wing: 6·5 mm.

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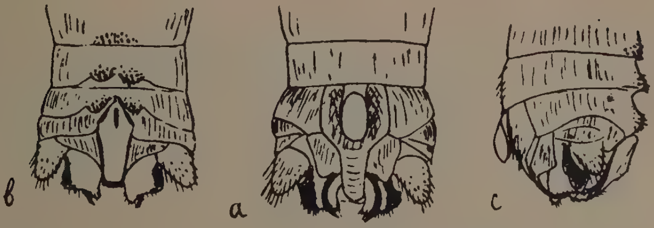

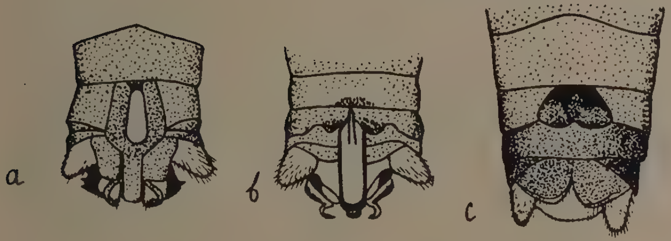

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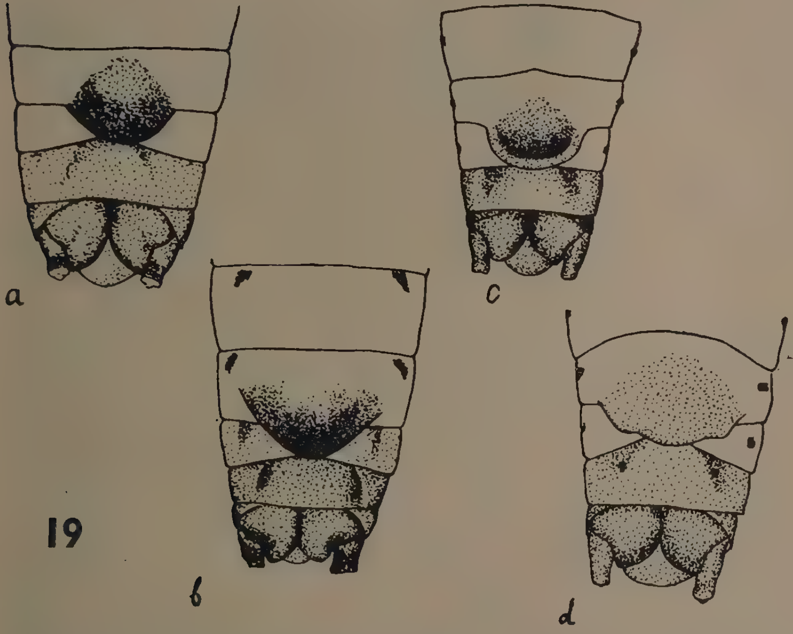

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Figs. 17–19.—(17) *Protonemura falciformis* Martynov. Abdomen of ♂ in ventral (*a*), dorsal (*b*) and lateral (*c*) view. (18) *Protoneumra oreas* Martynov. *a*, *b*, Abdomen of ♂ in ventral and dorsal view respectively; *c*, abdomen of ♀ in ventral view. (19) Female abdomens in ventral view: *a*, *Nemoura martynovia* Claassen; *b*, *Nemoura elegantula* Martynov; *c*, *Nemoura variegata* subspecies *caucasica* subsp. n.; *d*, *Nemoura variegata* typica from the vicinity of Kiev (for comparison).

Protonemura oreas Martynov.

BALKARIA: Stream Sokoshili-Su, 17.vii.1932, 1 ♀. KARACHAYEV LAND: Stream Baduk, 11.vii.1933, 1 ♂. BALKARIA: Adyr-Su valley, 11.viii.1939, 1 ♂, 1 ♀.; Adyr-Su valley, 3.viii.1939, 1 ♀.

The specimens listed here can be recognized as belonging to Martynov's species *Protonemura oreas* only with some reservations, as in some respects they differ from his description. The subanal plates are not triangular but approximately trapezoid (fig. 18*a*). The chitin rods are connected with the median edge of the subanal plates. The supra-anal lobe is adorned with two longitudinal lines (fig. 18, *b*) (according to Martynov it should be without any pattern). Martynov writes that *Protonemura oreas* is distinguished by the presence of a large spine on the lateral border of the intermediate process. The presence of two spines instead of one, together with some other characters, distinguishes the forma *longispinosa* Martynov belonging to the same species. Of the two males which I have studied one has two spines on the right process and one on the left process; the other specimen has two spines on the right process and none on the left. The number of spines on the intermediate process is consequently not a very reliable character. Unfortunately Martynov does not mention any specific characters which could serve to distinguish this species with a high degree of certainty. If the spines on the intermediate process were absent altogether one could identify my specimens as *Protonemura falciformis* Martynov. In the females the subanal plates of my specimens (fig. 18, *c*) are much shorter and rounder than as shown by Martynov.

Nemoura Pictet.

In this study I have met with three species of the genus *Nemoura* s. str.

Nemoura martynovia Claassen.

(= *Nemoura pallida* Martynov, nec *Nemoura pallida* Stephens.)

Although there is no doubt that the specimens studied by myself belong to the species *N. martynovia* (*N. pallida* Martynov) I find, nevertheless, some differences between my specimens and Martynov's description. It will therefore be useful to mention some characters.

Colouring very characteristic, although rather variable. Antennae uniformly blackish; only the first joint somewhat darker. Head distinctly multicoloured; anterior parts of a very dark brown, occiput varies between yellow and light brown. Margin between the two parts of head is given by a yellow line lying transversely behind posterior ocelli, which broadens at both ends into two yellow spots lying beside compound eyes. Pronotum with straight lateral margins and rather sharp anterior angles, light brown. Legs with a very characteristic pattern but in teneral specimens this pattern tends to be indistinct. General colour yellow. In middle part of tibia dorsally lies a broad transverse brownish band. Knees dark brown. Colouring of wings very variable; generally pale, with pale brownish veins. In darker specimens, and especially in large females, wings dark, with almost black veins, shaded in area of the pterostigma and the X-like figure. Abdomen pale yellow ventrally and brown dorsally. Tergites of abdomen decorated in most specimens with two yellow spots, one on each side of median line, but in some specimens these spots are absent and dorsal surface of abdomen is uniformly brown. This difference apparently not related to degree of colouring of a specimen, as very dark specimens are found with spots on the abdomen and pale ones with a uniform colouring.

Structure of male genital organs of the same general type as in *N. marginata* Pictet and *N. cambrica* Stephens. Vesicle of 9th sternite narrow and short. Cerci straight, thinner in their middle parts, expanding laterally on distal end. In ventral view cerci have the appearance of boots with the tip pointing laterally. Tip produced in a claw curving ventrad. Supra-anal lobe very broad, oval, with a notch at the end ; its external (morphologically ventral !) surface marked by two dark lines, which converge proximally (see fig. 20, *b*).

Martynov has not described the female of this species. The description of the colouring given above applies also to females. The occurrence of especially dark females has been noted already.

In the structure of its genitalia the female of *N. martynovia* also resembles *N. marginata* Pictet and *N. cambrica* Stephens. Subgenital plate rather small, evenly rounded posteriorly, moderately convex (fig. 19*a*). Posterior margin of 9th sternite slightly curved. Subanal plates blunt-triangular, rather deeply notched laterally (more than in *N. marginata* and *N. cambrica*).

Length of fore wing, ♂, 6·5–8 mm.
Length of fore wing, ♀, 7·5–10 mm.

BALKARIA : Terskol valley, 20.vii.1932, 4 ♂♂ and 5 ♀♀ ; River Djilki-Su, 15.vii.1932, 1 ♂ ; River Chegem, 13.vii.1932, 1 ♂ ; Adyr-Su valley, 3–14.viii. 1939, many ♂♂ and ♀♀. KARACHAYEV LAND : Dombai valley, 21.vii.1933, 3 ♀♀. SVANETIA : Nakra valley, 28.vii.1932, 1 ♀.

The species is abundant in small rivers and streams in the forest zone of the mountains.

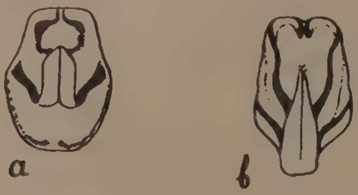
Nemoura elegantula Martynov.

This species is very distinct, and there is no doubt that my specimens belong to it. Martynov's description, however, is incomplete and even wrong in one essential point, so that it is desirable to give a rather detailed new description of the species.

Antennae distally black, proximally lighter coloured, blackish to yellow-brown, but the first two joints are darker. Head black, glossy. Eyes in the males extraordinarily large. Pronotum dark, black-brown, very short, with straight lateral margins, which converge posteriorly but slightly. Anterior angles of pronotum rounded. Legs of a bright lemon-yellow, middle part of the femur of an especially vivid colour. Femora with brown longitudinal lines on sides and sharply defined black spots on distal ends, which are continued on the proximal parts of the tibiae. Fore wings multicoloured ; in addition to a dark spot in the region of the anastomosis there are two distinct dark transverse bands ; one of which traverses distal part of wing (but does not reach posterior margin of same), the other band is curved and lies in proximal half of wing. Two light spots in proximal part of wing, one lying near the beginning of Rs and M, the other—near the beginning of Cu. In the area of these light spots veins are also of a light colour, lemon-yellow. In other parts of wing veins are blackish-brown. Posterior wings pale with brown veins. Ventral surface of abdomen pale yellow in males and more or less reddish-brown in females.

A distinctive feature of the genitalia in the male is the complete absence of the vesicle of the 9th sternite (fig. 21). In the description of *N. elegantula*, Martynov says that in his specimen the vesicle is torn off (Martynov had two males of this species at his disposal). I have studied 6 males of *N. elegantula* and in each one of them found the vesicle lacking. There is consequently no doubt that this cannot have been a chance occurrence.

Subanal lobes slightly concave both laterally and medially. Cerci curved in form of an S; expanded at the end both medially and laterally. Lateral outgrowth pointed and ends in a strong claw, which curves ventrad. Supra-anal lobe elliptical; distal part occupied by a roundish field, delimited by two short slanting chinitized lines; in the middle of this field lies a dark figure resembling a horse-shoe (fig. 20, *a*).



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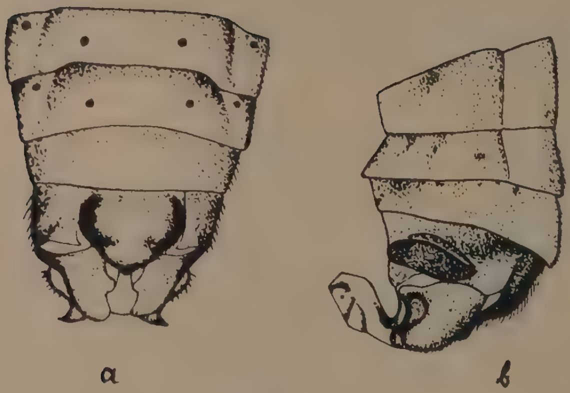

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Figs. 20–21.—(20) Supra-anal lobe in *Nemoura elegantula* Martynov (*a*) and in *Nemoura martynovia* Claassen (*b*). (21) *Nemoura elegantula* Martynov. Abdomen in ventral (*a*) and lateral (*b*) view.

The female has not been described by Martynov. The habitus corresponds to that of the male, but eyes not so very large and ventral surface of abdomen more reddish-brown. Subgenital plate very broad (more than ¾ of the breadth of the abdomen), approximately triangular, but with a rounded posterior angle. In some specimens plate seems to be trapezoid. Ninth sternite is not so much chitinized as is usual. Subanal plates very short, notched laterally. Cerci also very short (fig. 19, *b*).

That the males and females described above belong together is shown not only by a simultaneous occurrence and morphological likeness, but is also proved by a pair which were captured *in copula*.

Length of fore wing: In ♂♂, 5·5–6·5 mm.

Length of fore wing: In ♀♀, 7·0–8·0 mm.

SVANETIA: South slope of the Donguz-Orun pass, altitude approximately 2700–2800 m., 31.vii.1932, a ♂ and ♀ *in copula*. KARACHAYEV LAND: Amanaus valley on the edge of the glacier Amanus, 2—4.vii. 1933, 5 ♂♂ and 2 ♀♀; Mountain Musach Tara, altitude approximately 2600 m., 28.vii.1933, 1 ♀. BALKARIA: Adyr-Su valley, altitude 2400 m., 30.vii. 1939, 3 ♀♀; on the moraine of a glacier, 13.viii.1939, 2 ♀♀.

This pretty species, somewhat wasp-like in its appearance, inhabits small streams and springs above the forest zone, sometimes in the immediate vicinity of the snow-line. It is therefore the most alpine species of the Caucasian Plecoptera.

Nemoura variegata Oliv. subsp. **caucasica** subsp. n.

Martynov studied several flies of this species from the Caucasus and states that his specimens belong to two varieties: (1) *N. variegata* forma *castanea* Kempny (2 ♀♀), and (2) *N. variegata* forma *uninervulata* Martynov (2 ♀♀). The latter form is characterized by the presence of only one transverse vein between M and Cu1 and between Cu1 and Cu2 (Martynov designates the veins as M, Cu, and A_1) on the hind wings.

A study of my specimens showed me that the Caucasian population of *N. variegata* differs quite perceptibly from the typical form by a darker coloration and by a tendency to the reduction of the number of cross veins between M and Cu1 and between Cu1 and Cu2 on the hind wings. It seems that the peculiarities of the Caucasian specimens of *N. variegata* are not individual variations. These peculiarities distinguish the Caucasian population as a local subspecies, which I would like to name *N. variegata caucasica* subsp. n.

The peculiarities of the subspecies are the following:

(1) Smaller than the typical form. Length of fore wing in ♂♂ 6·5–7 mm., in ♀♀ 8–9·5 mm. (in a population of typical *N. variegata* from the vicinities of Kiev the length of fore wing in ♂♂ is 8–9·5 mm., in ♀♀ 9–11 mm.)

(2) Number of cross-veins between M and Cu1, and between Cu1 and Cu2 in posterior wings less than in typical form; total of these cross veins in one hind wing is in males 3–4, in females 2–6, most commonly 3–4 (in a population of the typical form from the vicinities of Kiev the total is 2–10 in males and 3–9 in females, most commonly 5–7).

I would like to stress that I have not found a single specimen of *N. variegata* of Caucasian origin with the lowest possible number, with a total of two cross veins on *each* of the hind wings. In the Kiev population, on the other hand, although the average number of cross veins is higher, I did find one male with only two cross veins on each of the hind wings—a true *forma uninervulata* Martynov. The form *uninervulata* is consequently an extreme variant of a broad range of variation.

(3) Coloration darker than in typical form. General shade of body darker; antennae darkened distally and tips almost black. Pattern on legs more distinct. Dark spots on

distal ends of femora especially distinct. Wings darkly shaded. Dark spots in region of X-like figure, which are especially prominent in some specimens. These latter specimens, which are again extreme variants, may be designated as the forma *castanea* Kempny.

(4) Subgenital plate of female more strongly chitinized and more heavily pigmented; posteriorly evenly rounded (fig. 19, *c*) and without prominent lateral angles which give a three-lobed appearance to the subgenital plate in the female of the typical form. Rounded contour of subgenital plate in specimens of *N. variegata* from the Caucasus has been noted by Martynov.

BALKARIA: Terskol valley, 20.vii.1932, 2 ♀♀. KARACHAYEV LAND: Amanaus valley, 29.vii.1933, 4 ♀♀. BALKARIA: Adyr-Su valley, 11.viii.1939, 2 ♂♂ and 4 ♀♀.

N. variegata caucasica subsp. n. inhabits approximately the same localities as *N. martynovia* Claassen, that is, small streams in the forest zone of the mountains.

The three Caucasian *Nemoura* species which I have been able to study can be easily distinguished in both sexes:

	N. martynovia Claassen.	*N. elegantula* Martynov.	*N. variegata caucasica* subsp. n.
Head . . .	Distinctly two-coloured, black in front, light-brown behind.	Black.	Brown.
Pronotum . .	Breadth not much exceeding length, straight sides and sharp anterior angles.	Very broad, breadth nearly twice the length.	Breadth not much exceeding length, laterally convex with rounded anterior angles.
Femora . . .	Yellow with a dark transverse band at mid-length.	Lemon-yellow with black ends.	Light brown with darker ends.
Wings . . .	Pale to dark, blackish, shadowed, especially in the region of the X-like figure.	Colourful, with dark transverse bands and lemon yellow spots on proximal parts.	Brownish, shadowed, especially in the region of the X-like figure, sometimes with distinct spots in this region.
Cerci of the ♂ . .	Straight, broadened at the end and produced laterally in a claw.	Bent in an S-shape, broadened at the end and produced laterally in a claw.	Straight, with two claws at the end (but the median claw is in *N. v. caucasica* very small).
Supra-anal lobe of the ♂	With two dark lines converging posteriorly.	With a horse-shoe-shaped spot in the middle of a distal field which is delimited by two oblique chitinized lines.	With an anteriorly directed pointed process in the middle.
Subgenital plate of the ♀.	Rounded posteriorly.	Triangular, with rounded posterior angle.	Rounded posteriorly.

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RECENT ADDITIONS TO THE BRITISH APHID FAUNA. PART I: *DACTYNOTUS* RAFINESQUE TO *RHOPALOSIPHUM* KOCH, C. L.

By H. L. G. Stroyan, M.A., F.R.E.S.

Manuscript received 28th March, 1950.

(Read 3rd May, 1950.)

Introduction.

The most recent published list of the British Aphididae is that of Kloet and Hincks, contained in their *Check-list of British Insects* (1945). Apart from numerous nomenclatural changes which have been introduced since that date, recent systematic work by Carl Börner in Germany and D. Hille Ris Lambers in Holland has shown the existence of a number of species hitherto confounded with others already known from earlier authors' descriptions. The present paper is an attempt to collate a few of these species which are now known to occur in Britain, and to present critical characters for recognition in cases where such diagnoses are not to be found in existing literature, or where such literature is not easily obtainable.

Locality records make no pretence of representing the range of the species in Britain; this would in any case be a matter of impossibility for most aphid species on account of their wide potentialities for dispersal by wind. The records are given solely to authenticate the occurrence of the species in question, and where possible the present whereabouts of the material referred to is also indicated.

Reference is made also to descriptions of other new species described from British material by various authors between the date of publication of the Kloet and Hincks list and the present time. This is in order to increase the possible usefulness of the present compilation as a supplement to the Check-list. No attempt is made, however, to bring up to date the synonymy of the latter list for species already known as British (except in cases where the *status quo* creates an ambiguity affecting the present paper), since this would render the paper too long under the present exigencies of publication.

The following is a list of the species discussed in the following pages:

1. *Dactynotus* (*Uromelan*) *similis* Hille Ris Lambers, 1935.
2. *Dactynotus* (*s.s.*) *pilosellae* Börner, 1933.
3. *Masonaphis rhododendri* (Wilson, 1918).
4. *Acyrthosiphon caraganae* (Cholodkovsky, 1907).
5. *Acyrthosiphon* (*Lactucobium*) *scariolae* Nevsky, 1929.
6. *Cryptaphis setiger* Hille Ris Lambers, 1947.
7. *Subacyrthosiphon cryptobium* Hille Ris Lambers, 1947.
8. *Aulacorthum speyeri* Börner, 1939.
9. *Metopolophium albidum* Hille Ris Lambers, 1947.
10. *Metopolophium frisicum* Hille Ris Lambers, 1947.
11. *Metopolophium tenerum* Hille Ris Lambers, 1947.

12. *Amphorophora gei* (Börner, 1939).
13. *Megourella purpurea* Hille Ris Lambers, 1949.
14. *Rhopalosiphoninus* (*Submegoura*) *obscurata* Hille Ris Lambers, 1950.
15. *Myzus ascalonicus* Doncaster, 1946.
16. *Myzus* (*Prunomyzus*) *padellus* Rogerson and Hille Ris Lambers, 1947.
17. *Ovatus glechomae* Hille Ris Lambers, 1947.
18. *Ovatomyzus stachyos* Hille Ris Lambers, 1947.
19. *Brachycaudus klugkisti* (Börner, 1942).
20. *Brachycaudus linariae* Stroyan, 1950.
21. *Anuraphis subterranea* ssp. *catonii* Hille Ris Lambers, 1935.
22. *Acaudinum centaureae* (Koch, 1857).
23. *Sappaphis bonomii* (Hille Ris Lambers, 1935).
24. *Sappaphis choerophylli* (Börner, 1940).
25. *Sappaphis hirsutissima* (Börner, 1940).
26. *Sappaphis lauberti* (Börner, 1940).
27. *Nasonovia pilosellae* (Börner, 1933).
28. *Cavariella archangelicae* (Scopoli, 1763).
29. *Cavahyalopterus noxius* (Mordvilko, 1914).
30. *Galiobium langei* Börner, 1933.
31. *Stägeriella necopinata* (Börner, 1939).
32. *Myzaphis bucktoni* Jacob, 1946.
33. *Rhopalosiphum maidis* (Fitch, 1855).
34. *Macrosiphoniella chamomillae* Hille Ris Lambers, 1947.

The second part of the paper will deal with the remaining genera from *Rhopalomyzus* Mordvilko onwards, and will include notes on a few species, originally described as British, which were omitted from the Kloet and Hincks list, since at that time nothing adequate was known about them; but which have been the subjects of recent papers which enable them to be reintroduced into the British list with a full and adequate status.

The order of genera adopted in this paper does not pretend to represent a natural classification, since the complex intergrading of generic characters found in aphids makes this almost impossible except in a few limited groups at present; but where the present state of knowledge enables two or three genera or more to be grouped together with some certainty such a grouping has been adhered to.

1. *Dactynotus* (*Uromelan*) *similis* Hille Ris Lambers, 1935.

A full account of this species is to be found in Part II of the *Contributions to a Monograph of the Aphididae of Europe* by Hille Ris Lambers (1939, *vide* bibliography). The species was first described by the above author (1935) from the inflorescences of *Erigeron acer*, and in the British Isles it has been recorded on this food-plant from Essex (Horndon-on-the-Hill, 29.vii.48) by *V. F. Eastop*, and from Devon (Heathfield) and Somerset (Leigh Woods, Bristol) by *H. G. Morgan.*

2. *Dactynotus* (*s.s.*) *pilosellae* Börner, 1933.

This species, of which a full account may also be found in Part II of the Hille Ris Lambers monograph, is confined, so far as is known, to *Hieracium pilosella*; the specific characters separating it from *D. obscurus* (Koch), which also inhabits the same host among other species of *Hieracium*, being the generally smaller size and the longer reticulated area at the apex of the siphunculi. Dr. Hille Ris Lambers has, however, indicated to the writer some doubt as to whether these characters will hold good for all material of both species, and the question would thus perhaps arise whether to regard *pilosellae* as a good species or as a small subspecies of *obscurus* living only on *Hieracium pilosella*.

The British status of *pilosellae* at the present time depends on 5 alatae caught in traps by Drs. Broadbent and Doncaster, and shown to the writer by them. One of these specimens had been submitted to Dr. Hille Ris Lambers, who confirmed the identification. Nothing more is known of the species in Britain at present, but it can hardly fail to occur here in plenty, since it is found in suitable spots in parts of the Continent adjacent to this country, and its host-plant is very abundant in Britain. The question of its identity or otherwise with *D. obscurus* must await further examination of authentic material.

The measurements of two of the alatae referred to above are as follows :

(1) Body 1·81 mm., antenna without joints I and II 2·06 + mm. (part of processus terminalis missing), siphunculi 0·46 mm., cauda 0·24 mm., caudal hairs 9, apical joint of rostrum 0·16 mm., antennal joint ratios (III to VI) 43 : 26 : 22 : 7 + 31 +, rhinaria on III 48 and ? (missing).

(2) Body 2·00 mm., antenna without joints I and II 2·62 mm., siphunculi 0·54 mm., cauda 0·29 mm., caudal hairs 12, apical joint of rostrum 0·17 mm., 2nd joint of hind tarsus 0·11 mm., antennal joint ratios 48 : 31 : 24 : 8 + 53, rhinaria on III 39 and 39.

3. *Masonaphis rhododendri* (Wilson, 1918).

This species, which is confined to *Rhododendron* and *Azalea* spp., has been recorded in this country three times so far : on Azaleas imported from Holland at Hull Docks (*J. H. Fidler*, 1949) ; on Azaleas under glass at Maidenhead, Berks, 29.iii.49 (*D. W. Empson*, unpublished) ; and on Rhododendrons in the open at the R.H.S. Gardens, Wisley, Surrey (*G. Fox Wilson*, 1939).[1] For information about the latter record, which was made under the name *Amphorophora rhododendronia* Mason, the writer is indebted to Dr. J. H. Fidler.

The morphological features diagnostic for *M. rhododendri* (vide Hille Ris Lambers, 1939) are the slightly and regularly swollen siphunculi resembling in shape those of *Amphorophora rubi* (Kaltenbach), but having a distinct reticulate area at the apex, coupled with the chaetotaxy of the first tarsal joints, which have 5 hairs on all legs. This combination of characters does not occur in any related genus.

4. *Acyrthosiphon caraganae* (Cholodkovsky, 1907).

Hille Ris Lambers (1947 : 222) gives a complete description of this species. The only authenticated record yet known to the writer is of specimens collected by Mr. V. F. Eastop at Reading, Berks, on *Colutea orientalis*. In these specimens the number of secondary rhinaria on ant. III varies from 0 to 2 (apterae) ; and this, taken together with the length of the processus terminalis, which is longer than the figure given by Hille Ris Lambers for normal fundatrices, but shorter than that for normal apterae, suggests that these may be first generation fundatrigeniae. The writer is indebted to Mr. Eastop for the gift of a slide of this material.

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[1] Further records of this species are : Bourn, Cambs, on Azaleas and *Tulipa* in a glasshouse, 22.xii.49 (*E. Judenko*) ; Cambridge, many reared from Azalea bought in the market, January–February, 1950 (*H. L. G. Stroyan*). The former material is in the writer's possession also through the kindness of Dr. Judenko.

Measurements of one aptera (Reading, Berks, 3.v.48): Body 3·49 mm., antenna without joints I and II 2·37 mm., joint ratios (III to VI) 47 : 31 : 30 : 10 + 30, siphunculi 0·94 mm., cauda 0·42 mm., caudal hairs 8, apical joint of rostrum 0·13 mm., 2nd joint of hind tarsi 0·16 mm., secondary rhinaria on ant. III 0 and 1.

5. *Acyrthosiphon* (*Lactucobium*) *scariolae* Nevsky, 1929.

A complete description is given by Hille Ris Lambers (1947 : 255). The writer is indebted to Mr. V. F. Eastop for the opportunity of examining specimens collected from *Lactuca serriola* at Fobbing, Essex, on 16th July, 1948. The rather acute apical rostral joint of this species, armed with an unusually large number of hairs, is characteristic.

Measurements of one specimen (Fobbing, Essex, 16.vii.48): Body 2·40 mm., antenna without joints I and II about 2·19 mm. (processus terminalis crushed), joint ratios 42 : 26 : 24 : 11 + (34 ?), siphunculi 0·66 mm., cauda 0·20 mm., caudal hairs 9, apical joint of rostrum 0·14 mm., 2nd joint of hind tarsi 0·19 mm., secondary rhinaria on ant. III 6 and 6.

6. *Cryptaphis setiger* Hille Ris Lambers, 1947.

This species was originally described by Hille Ris Lambers in Part III of his *Contributions to a Monograph of the Aphididae of Europe*, p. 298. He refers in a footnote to an alata identified by himself and taken in a sticky trap in England by Dr. J. P. Doncaster. Nothing is known to add to this single record of the species in this country; it probably occurs in suitable localities, and its cryptic biology is probably responsible for the lack of records. Hille Ris Lambers gives *Festuca ovina* and *Holcus mollis* as food-plants. The aphids occur at ground level on superterranean parts emerging from under stones in shadowed or damp localities.

7. *Subacyrthosiphon cryptobium* Hille Ris Lambers, 1947.

A full description of this new genus and species is to be found in Hille Ris Lambers (1947, *loc. cit.* : 260 *et seq.*). The host plant is *Trifolium repens*, on which the species spends its whole life; it is hard to find on account of its habit of living on the prostrate stems, from which it lets itself fall at the least disturbance of the plant.

Only one British specimen is known to the writer, an alata without any data among slides containing trapped aphids lent by Dr. J. P. Doncaster for examination. This specimen was identified by Dr. Hille Ris Lambers. Probably this aphid, like *Cryptaphis setiger* Hille Ris Lambers, only awaits discovery on its host-plant in this country.

The measurements of the single known British alata are as follows: Body 2·29 mm., antenna without joints I and II 2·67 mm., joint ratios 40 : 32 : 30 : 12 + 53, rhinaria on III 8 and 8, siphunculi 0·42 mm., cauda 0·22 mm., caudal hairs ? 6 (2 broken ?), apical joint of rostrum 0·13 mm., 2nd joint of hind tarsi 0·11 mm. The specimen has the median of the left fore wing only once forked, that of the right normal.

8. *Aulacorthum speyeri* Börner, 1939.

This species is keyed by Hille Ris Lambers in the introductory part of his treatment of *Aulacorthum* Mordvilko (Hille Ris Lambers, 1947), but the full description is included in the fourth part of the same work (1949). A photograph of the apterous vivipara is to be found on Plate XIV, fig. 12, in the earlier part. The species is monophagous on *Convallaria majalis.* Börner's original description (1939) is rather inaccessible, and in view of the distinctness of the species it is not necessary to quote from it for the purposes of the present account. In the apterae the siphunculi, which are pale with dark bases and apices, and the uninterrupted black sclerotic areas across the abdominal dorsum, are characteristic. The alatae show the same characters, though with the abdominal sclerotization rather more broken up into bars. The number of rhinaria on the IIIrd antennal joint in the alatae is very small, fewer than in *A. rufum* Hille Ris Lambers (3 to 7 in the two British examples examined).

The only British material of this species known to the writer consists of two alatae taken in traps by Dr. J. P. Doncaster, the data for which are Manea, Cambs., July, 1942, and Lincoln, 4.vii.45. These specimens were identified by Dr. Hille Ris Lambers.

The measurements of the specimens are given herewith :

(1) Body 2·48 mm., antennae without joints I and II 3·30 mm., joint ratios for all joints 11 : 6 : 50 : 41 : 37 : 12 + 69, rhinaria on III 4 and 7, siphunculi 0·56 mm., cauda ?, caudal hairs 7, apical joint of rostrum 0·14 mm. (Manea, July, 1942).

(2) Body 3·15 mm., antennae without I and II 3·42 mm., ratio for joints III to VI 53 : 46 : 35 : 13 + 67, rhinaria on III 6 and 3, siphunculi 0·59 mm., cauda 0·29 mm., caudal hairs 7, apical joint of rostrum 0·14 mm. (Lincoln, 4.vii.45.)

9. *Metopolophium albidum* Hille Ris Lambers, 1947.

The original description of this species is contained in Part III of the Hille Ris Lambers *Contributions* (1947). The host plant of the species is *Arrhenatherum elatius*, although when abundant it will readily transfer its attentions to other meadow grasses during the summer months. It is a widespread and abundant species throughout the eastern and southern counties, and probably occurs in plenty wherever its host is found in any quantity. In favourable years it may do much damage to meadow grasses, becoming locally the commonest *Metopolophium* in pastures or on road verges ; a heavy attack causes a red and yellow streaky discoloration of the grass blades. Like other species of the genus it is heavily attacked by hymenopterous parasites when common.

The species may be distinguished from *M. dirhodum* (Walker) by its pale yellowish colour and long slender siphunculi, and also by the gradual darkening from base to apex of the antennae—that is, the apices of the antennal joints are not, as in *dirhodum*, darker than the bases of the succeeding joints. From all the other species of *Metopolophium* it is easily separated by its greater size and pale colour.

Measurements of one aptera and one alata :

Aptera : Body 2·22 mm., antenna without joints I and II 2·03 mm., joint ratios 37 : 24 : 20 : 10 + 36, siphunculi 0·51 mm., cauda 0·27 mm., caudal hairs 6, apical joint of rostrum 0·10 mm., 2nd joint of hind tarsi 0·12 mm., secondary rhinaria on ant. III 1 and 1.

Alata: Body 2·83 mm., antenna without joints I and II 2·56 mm., joint ratios 43 : 34 : 27 : 12 + 44, siphunculi 0·56 mm., cauda 0·29 mm., caudal hairs 7, apical joint of rostrum 0·10 mm., 2nd joint of hind tarsi 0·13 mm., secondary rhinaria on ant. III 10 and 10.

Both the above specimens were swept from *Arrhenatherum* at Shepreth, Cambs., 11.v.48.

10. *Metopolophium frisicum* Hille Ris Lambers, 1947.

Original description in Hille Ris Lambers (1947), as for *albidum* Hille Ris Lambers. The species occurs typically on species of *Poa* growing in damp situations in rather heavy shade, and is the most local of the five species known from Western Europe. So far it is only known as British from two alatae taken in 1936 at Reigate, Surrey, by Prof. Essig, and from a series bred by the writer from *Poa pratensis* growing in a water-meadow at Hauxton Mill, Cambs., between February and April, 1949. In this latter case the aphids had evidently over-wintered viviparously at the bases of the tufts of grass and *Anthriscus* growing close to the river bank; a fair proportion of the larvae collected in the field proved to be parasitized.

M. frisicum may be distinguished from its near relatives *festucae* and *tenerum* by the smoky coloration of the dorsum in the mature apterae, due to a yellowish sclerotization of the integument, by the generally smaller and slenderer build and by the thin, strongly-flanged siphunculi. It may occur in the same habitats with *festucae*, but is never likely to be encountered in the same localities as *tenerum*, whose host and habitat preferences are entirely different.

Measurements of one aptera and one alata:

Aptera: Body 1·95 mm., antenna without joints I and II 1·58 mm., joint ratios 29 : 18 : 17 : 10 + 25, siphunculi 0·45 mm., cauda 0·19 mm., caudal hairs 5, apical joint of rostrum 0·09 mm., 2nd joint of hind tarsi 0·10 mm., secondary rhinaria on ant. III 2 and 0.

Alata: Body 1·81 mm., antenna without joints I and II 1·73 mm., joint ratios 30 : 20 : 17 : 10 + 31, siphunculi 0·34 mm., cauda 0·13 mm., caudal hairs 5, apical joint of rostrum 0·09 mm., 2nd joint of hind tarsi 0·10 mm., secondary rhinaria on ant. III 19 and 18.

Both the above specimens from culture from *Poa pratensis*, Hauxton Mill, Cambs., March-April, 1949.

11. *Metopolophium tenerum* Hille Ris Lambers, 1947.

Original description as for two preceding species. The present species is ecologically very stenotopic, being found only on the narrow-leaved grasses *Festuca ovina* or *F. rubra* and *Deschampsia flexuosa* where these grow in dryish but well-shaded situations, such as under pine trees. It has been recorded in Britain so far only from the North of England (Leeds, 9.vi.44 and 2.vii.46 (*H. W. Thompson*)) and from North Wales (Bangor, Caerns. (*A. W. Colling*)). The morphology is very similar to that of *M. festucae*, especially in slides, but from the latter species it may be distinguished by the shorter processus terminalis, which is appreciably less than 3 times as long as the basal part of the VIth joint, while in *festucae* it varies from 3 to $3\frac{3}{4}$ times the basal part of VI. In life the somewhat shiny, bloated appearance of the apterae, varying from pale green to reddish and appearing as if parasitized even when perfectly healthy, is very characteristic of *tenerum*.

Measurements of one aptera and one alata :

Aptera : Body 1·52 mm., antenna without joints I and II 1·36 mm., joint ratios 22 : 15 : 14 : 9 + 25, siphunculi 0·30 mm., cauda 0·18 mm., caudal hairs 6, apical joint of rostrum 0·10 mm., 2nd joint of hind tarsi 0·10 mm., secondary rhinaria on ant. III 2 and 1.

Alata : Body 1·81 mm., antenna without joints I and II 1·50 mm., joint ratios 26 : 18 : 17 : 10 + 23, siphunculi 0·32 mm., cauda 0·19 mm., caudal hairs 6, apical joint of rostrum 0·10 mm., 2nd joint of hind tarsi 0·10 mm., secondary rhinaria on ant. III 4 and 4.[1]

Both above from *Deschampsia flexuosa*, Leeds, 2.vii.46.

Note.—Myzus festucae Theobald, which appears in the Kloet and Hincks list as a synonym of *Metopolophium dirhodum* (Walker), is now known to be specifically distinct, living holocyclically on cereals and meadow grasses of all kinds, frequently overwintering in the viviparous state, and being responsible for nearly all the economically damaging outbreaks of *Metopolophium* recorded in the literature. Its distribution is potentially universal, any form of grassland being suitable as reservoirs of population, and it is capable of severely stunting crops of winter oats. The cereal form was for a time considered tentatively to be a distinct species or subspecies, but the differences between the forms are found to grade into each other to give a continuous range of variation, and the larger size and stronger markings of the cereal " race " are presumably nutritional effects. A full description of *festucae* is to be found in Hille Ris Lambers' treatment (*loc. cit.*) of *Metopolophium*.

12. *Amphorophora gei* (Börner, 1939).

Original description in Börner (1939). This large and easily recognizable species is to be found on the undersides of the leaves of *Geum rivale*, or more rarely *Geum urbanum*, in damp, well-shaded situations. Its history in this country is confined to alate specimens taken in sticky traps by Drs. L. Broadbent and J. P. Doncaster, and lent to the writer by them for identification. It is probably to be found in suitable localities fairly commonly, but requires a careful search to reveal it.

The following morphological notes have been made from one of the above-mentioned trapped alatae lent by Dr. Doncaster, and bearing no data save the numeral " 4.x.5 " ; and from three apterae taken in Dutch Limburg by Dr. Hille Ris Lambers and the writer in June, 1949.

Apterous viviparous female : Pale green or yellowish-green, nude. Body large, plump spindle-shaped. Head with a deep frontal emargination between the prominent, somewhat diverging frontal tubercles, which are scabrous on their internal surfaces. The frontal hairs and those on the first and second antennal joints are prominent and $1\frac{1}{2}$ × as long as the articular diameter of the third antennal joint ; those on the rest of the antennae (joints III–VI) are rather shorter, only about half this length, joint III with about 17–20 such hairs. Antennae longer than body, joints III and IV almost smooth, V and VI somewhat imbricate, joint I much larger than II and somewhat rough ; a small group of from 4 to 10 secondary rhinaria crowded together on the basal quarter of III, this portion of the joint being slightly incrassate. Rostrum short, reaching to just beyond second coxae ; apical joint shortish, acute triangular, with two pairs of hairs in addition to the apical pairs. Vertex with 4 pairs of long, stoutish but acute hairs, of the same length

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[1] This rhinarial number is abnormally low; two other typical alatae show 16, 15 and 12, 12 respectively on the IIIrd antennal joints.

as the frontal hairs; eyes large and prominent. Body cuticle entirely membranous and featureless; dorsal body hairs rather short but acute, somewhat longer on 8th tergite; ventral hairs showing a rather irregular variation from shortish to long and acute in different specimens and on different segments of the abdomen. Siphunculi about two-thirds the length of joint III of antennae, pale; expanded at base, narrowest from about one-quarter to just before one-half, thereafter sharply and markedly swollen, with greatest diameter (about twice least diameter) at about three-quarters, contracting again to apex; a very marked flange at apex, preceded by about 3 imbricate annular striations; basal half somewhat wrinkled as in *Rhopalosiphoninus* species. Cauda rather short, blunt, about four-ninths siphunculi, with 7 or 8 hairs arranged more or less in pairs, with one median subapical one. Legs pale, slightly darker at apices of tibiae and on tarsi; coxae scabrously spinulose beneath and clothed with a few long acute hairs; tibial hairs of moderate length, between that of the frontal and antennal hairs. Rudimentary gonapophyses 3. Chaetotaxy of first tarsal joints 3.3.3.

Measurements of one aptera: Body 2·96 mm., antenna without joints I and II 3·26 mm., joint ratios 56 : 41 : 29 : 11 + 67, siphunculi 0·72 mm., cauda 0·29 mm., caudal hairs 8, apical joint of rostrum 0·18 mm., 2nd joint of hind tarsi 0·13 mm., secondary rhinaria on ant. III 5 and 4. (*Geum urbanum*, Gulpen, South Limburg, 28.vi.49.)

Alate viviparous female (from one specimen): Morphology very similar to aptera in nearly all respects. Cephalic and antennal hairs slightly shorter than in Dutch apterae. Antennae proportionally longer than in apterae, uniformly sclerotic except for extreme base of III, which is slightly paler. Joint III with 19 secondary rhinaria in a single row along whole length, becoming sparser on apical fourth. Dorsum of abdomen with pale transverse sclerotic bars on segments 1 to 5 inclusive, large marginal sclerites on 2 to 6 inclusive, and smaller ones on 7; those of 5 and 6 extend inwards to form ante- and post-siphuncular sclerites respectively. Eighth tergite with 8 hairs. Subgenital plate with posterior margin armed with short, stout hairs, and with a single asymmetrical pair on the right side in the anterior half. Such an anterior pair is not to be seen in the apterae described. Apices of femora, tibiae and siphunculi, and the tarsal joints, are slightly darkened, but the exact degree of sclerotization is not easily determined, as the specimen has been treated with potash.

Measurements of specimen: Body 2·80 mm., antenna withouts joints I and II 3·42 mm., joint ratios 55 : 47 : 36 : 13 + 63, siphunculi 0·61 mm., cauda 0·27 mm., apical joint of rostrum 0·18 mm., secondary rhinaria on ant. III 19 and ?, caudal hairs 8. (Trapped specimen in collection of Dr. J. P. Doncaster, data 4.x.5.)

The apterous viviparous females described above are in the author's own collection. Alate viviparous females are in the collections of Drs. J. P. Doncaster and L. Broadbent, the specimens having been taken at Edinburgh.

Note.—The first record of the species on its host plant is provided by apterae and alatae taken in numbers from *Geum urbanum* at Cambridge on 9.v.50, where they occurred mixed with *Myzus persicae* (Sulzer) and *Aulacorthum solani* (Kaltenbach) (*H. L. G. Stroyan*).

13. *Megourella purpurea* Hille Ris Lambers, 1949.

The full original description in Part IV of Hille Ris Lambers' *Contributions* (1949) renders any further morphological or biological detail superfluous here. The species, which is holocyclic on *Lathyrus*, is closely related to *M. tribulis* (Walker), from which it is distinguished by the tibial character quoted by the describer, viz. that in the present species the extreme bases of the tibiae are paler than the immediately succeeding parts of the tibial shaft, while in *tribulis* the whole shaft is concolorous. The colour of the insect in life varies from a dull purplish to a dirty yellow-green, the former colour apparently representing the usual red form found throughout many genera of the Macrosiphini. The species may be obtained by sharp thrashing of well-grown bushy plants of its host.

The only two British records so far refer to alate viviparous females trapped by Drs. L. Broadbent and J. H. Fidler at the Rothamsted Experimental Station, Harpenden, and Fulford, York, on 10.vii.46 and 16.v.48 respectively, and sent to the writer for identification. The former specimen had provisionally been identified as *tribulis*, and a careful examination of all material of the latter species in slide collections might reveal further examples of the same confusion.

The measurements of one aptera (from Uppland, Sweden, 11.viii.48) and one alata (the Fulford specimen) are given herewith :

Aptera : Body 2·35 mm., antenna without joints I and II 2·29 mm., joint ratios 45 : 26 : 23 : 10 + 39, siphunculi 0·36 mm., cauda 0·24 mm., caudal hairs 6, apical joint of rostrum 0·11 mm., 2nd joint of hind tarsi 0·12 mm., secondary rhinaria on ant. III 2 and 3.

Alata : Body 2·37 mm., antenna without joints I and II 2·96 mm., joint ratios 48 : 39 : 32 : 13 + 53, siphunculi 0·38 mm., cauda 0·24 mm., caudal hairs 6, apical joint of rostrum 0·13 mm., 2nd joint of hind tarsi 0·11 mm., secondary rhinaria on ant. III 26 and ?, on IV 9 and ?.

Material (alatae) in the collections of Drs. Broadbent and Fidler.

Note.—A third alata, also identified as *M. tribulis*, was found by the writer among trapped material belonging to Dr. J. P. Doncaster. This specimen was trapped at Ampthill, Beds, 26.vi.42.

14. *Rhopalosiphoninus* (*Submegoura*) *obscurata* Hille Ris Lambers, 1950.

The description of this species was prepared for inclusion in Part IV of Hille Ris Lambers' *Contributions to a Monograph of the Aphididae of Europe*, published in 1949. Circumstances prevented the publication of this part in the size originally planned, and among the species held over for the next number is *Submegoura obscurata*. Dr. Hille Ris Lambers has confirmed, in a letter, that the description will appear by the end of this year, and suggested that the name might be included in the present list as a *nomen nudum* pending publication of the next volume of *Temminckia.* This course has therefore been adopted, and no morphological details are given here.

The British status of *R.* (*S.*) *obscurata* rests at present on two alate viviparous females taken on sticky traps at Lincoln in 1944 and 1945 (*J. P. Doncaster*), and about 20 alatae and 60 apterae collected by the author from *Vicia cracca* growing in dry oak woodland near West Byfleet, Surrey, on the 16th and 18th August, 1949. Associated with the aphids in this latter habitat were larvae and an adult of *Eumicromus angulatus* (Stephens), a rare and little known Hemerobiid (Stroyan, 1949). It is possible that *obscurata* may prove to be widely distributed, but its very circumscribed ecology, which will be mentioned in the description, makes it unlikely that the species could ever be easily found ; even Dr. Lambers tells me that he has been unable to find the aphids at all frequently.

Slides of this species have been deposited in the collections of the British Museum (Natural History) and the Department of Zoology, Cambridge University ; the rest of the material referred to remains in the possession of Dr. J. P. Doncaster and the author.

It may be noted here that for a number of years before 1945 *Rhopalosiphoninus latysiphon* (Davidson) was erroneously reported as British. The *R. latysiphon* of Theobald appears to be a synonym of *R. staphyleae* (Koch). The true *latysiphon* was first recorded in Britain in 1945, since when it has become a considerable nuisance on bulbs under glass and stored potato tubers. It has been given the name of " Bulb and Potato Aphid " by Thomas (1948). Characters separating *latysiphon* from *staphyleae* are : (1) Antennal and tibial hairs much longer and more conspicuous in *latysiphon* than in *staphyleae* ; (2) the central swollen part of the siphunculi abruptly swollen as if blown out in *latysiphon*, more gradually vasiform in *staphyleae* ; the basal and apical constricted parts much longer in *latysiphon* than in *staphyleae*, nearly cylindrical and the basal part strongly wrinkled ; (3) the alate viviparae of *latysiphon* lack the strong shading of the wing veins usually apparent in *staphyleae* ; and (4) the dorsum of the apterae of *latysiphon* is more or less smoky sclerotic over the whole surface, with a very marked reticulation of fine spinulose sculpturing, while in *staphyleae* the dorsal pattern is less extensive and rather broken up.

15. *Myzus ascalonicus* Doncaster, 1946.

Since its original description (Doncaster, 1946) this species has become well-known to all workers on British aphids as one of the most euryphagous of all economically important species, even outstripping in this respect such species as *M. persicae* (Sulzer) and *Aphis fabae* Scop. The origin of the species remains something of a mystery, and seems as if it may remain so ; sexuales are still unknown, and it seems likely that in fact they do not occur. The damage done by the species is most apparent in the winter and spring months, when it is concentrated on bulbs and other cultivated plants ; during the summer it disperses to a very wide variety of hosts, but usually escapes notice on account of its cryptic habits, since it lives on etiolated shoots or other parts lying hidden under stones or other shelter. One economic aspect of the species which does not appear so far to have been mentioned in literature is the damage it does during the winter months to *Viola* species, curling the leaves into crisp crumpled bunches.

16. *Myzus* (*Prunomyzus*) *padellus* Rogerson and Hille Ris Lambers, 1946.

Originally described by the co-authors in 1946 from *Prunus padus* at Houxty on Tyne in 1943 and 1945. The writer knows of no further records of the species to date.

17. *Ovatus glechomae* Hille Ris Lambers, 1947.

Described by Hille Ris Lambers (1947*a* : 299) from the superterranean parts of *Glechoma hederacea* growing under and between stones, and hitherto known only from Wageningen and Bennekom in Holland, this species is, nevertheless, probably widespread and common under suitable ecological conditions. It occurred in numbers from July to September, 1949, on the stems of Glechoma growing under old brickbats on a pile of rubble in the author's garden at Great Wilbraham, Cambs. The aphids occurred in small colonies, particularly on the more etiolated shoots, but also spread over on to the more normal and less completely concealed stems, though never on to any shoots exposed to direct light.

When disturbed they tend to let themselves drop rather readily and get lost among the crevices of the bricks or stones. All the specimens taken in this locality were of a dark, dirty brown colour, with little or no trace of the green colour referred to by Hille Ris Lambers; the young larvae and nymphs are pale pinkish to ochreous brown.

The complete original description (*loc. cit.*) renders any detailed morphological notes superfluous here. Hille Ris Lambers has called attention to two characters which are diagnostic for the alate viviparous female, viz. the small number of secondary rhinaria on the antennae and the very large protruding primary rhinarium on ant. V. Where apterae are collected on the host plant the stenotopic ecology should render confusion with other members of the genus impossible; the only other species likely to be found in similar situations is *Myzus ascalonicus* Doncaster, and from this aphid the present species is readily distinguishable by the cylindrical siphunculi and the darker colour when alive and by the distinctly reddish or pinkish tinge in the immature forms.

Measurements of one aptera (Great Wilbraham, 28.vii.49): Body 1·62 mm., antenna without joints I and II 1·68 mm., joint ratios 26 : 22 : 19 : 7 + 31, siphunculi 0·32 mm., cauda 0·13 mm., caudal hairs 4, apical joint of rostrum 0·11 mm., 2nd joint of hind tarsi 0·08 mm.

Measurements of one alata (Great Wilbraham, 28.vii.49): Body 1·79 mm., antenna without joints I and II 1·89 mm., joint ratios 27 : 24 : 22 : 8 + 37, siphunculi 0·29 mm., cauda 0·13 mm., caudal hairs 5, apical joint of rostrum 0·12 mm., 2nd joint of hind tarsi 0·08 mm., secondary rhinaria on ant. III 11 and 14, on IV 6 and 7, on V 3 and 4.

Material of this species has been deposited in the collections of the British Museum of Natural History and the Department of Zoology, Cambridge University; further material in the writer's own collection.

18. *Ovatomyzus stachyos* Hille Ris Lambers, 1947.

This new genus and new species was described (Hille Ris Lambers, 1947*a*: 306) from material collected in the Arboretum at Wageningen, Holland, on the undersides of the leaves of a *Stachys* referred to as "*Stachys ? germanica* (the cultivated species sold as *Stachys lanata*)." The author has specimens collected in July, 1949, from *S. lanata* in his garden at Great Wilbraham, Cambs., and one or two specimens were also noted on leaves of both *S. lanata* and the true *S. germanica* (a somewhat less tomentose species) in the Botanical Garden of Cambridge University in the same month. The aphids occurred very sparsely in both localities, and so far only apterae have been collected. Their habits are exactly similar to those of *Ovatoides inulae* (Walker) on *Pulicaria dysenterica*; they live dispersed under the tomentum clothing the undersides of the leaves, more particularly the basal leaves, of these two *Stachys* species, and perhaps of any other *Stachys* with more or less of a woolly covering. Their colour, a very pale whitish yellow, renders them extremely hard to see under the dense hairs, and their fragility makes it difficult to collect them without damage, so that the best way is probably to collect the infested leaves and allow them to dry out until the aphids walk off of their own accord.

Morphological features diagnostic for *O. stachyos* are: in the apterae the long, very thin and flangeless siphunculi and the fairly well developed, angular but not projecting frontal tubercles, which are not scabrous or spinulose; in the alatae the sclerotic abdominal ornamentation as in *Myzus*, coupled with the long thin siphunculi as in apterae and the absence of small spinules between the apical tibial hairs; in both forms the absence of any trace of a projecting triommatidion at the posterior border of the compound eye.

Measurements of one aptera (Great Wilbraham, Cambs., 2.vii.49): Body 0·96 mm., antenna without joints I and II 1·07 mm., joint ratios 16 : 12 : 11 : 5 + 24, siphunculi 0·26 mm., cauda 0·11 mm., caudal hairs 6, apical joint of rostrum 0·10 mm., 2nd joint of hind tarsi 0·06 mm.,

Material (apterae) in the author's collection.

19. *Brachycaudus klugkisti* (Börner, 1942).

Börner (1942) describes this species as follows: "Naheverwandt mit *A*(*caudus*) *lychnidis* L. Unterschieden durch die Rückenborsten, die vom Kopf bis zum 6(7).Hinterleibsring deutlich fein geknöpft sind, Knöpfchen langlich; bei *lychnidis* sind diese Borsten auf dem Vorderrumpf stumpflich, auf den übrigen Ringen lang und fein gespitzt. Die Länge der Rückenborsten ist bei *klugkisti* durchweg etwas kürzer als bei *lychnidis*, das gilt auch für die Borsten an Fühlern und Beinen; am 3–4 Fühlerglied sind sie bei *klugkisti* $\frac{1}{2}$–$\frac{3}{5}$ so lang wie der Glieder dick. Körperlänge der bisher allein bekannten ungeflügelten Jungfern etwa 2 mm."

This description is quoted in full on account of certain discrepancies which have become apparent during the examination of a fair amount of English material.

In 1947 the writer observed that there appeared to be two species present among material of *Brachycaudus* from *Lychnis* spp.; and Dr. Hille Ris Lambers was good enough to draw attention to the paper by Börner quoted above.

When British aphids from *Lychnis* are examined they are easily separable on the basis of Börner's antennal hair character into those with the hairs on ant. III about half as long as the width of the joint (*klugkisti*) and those with the hairs about equal to the width of the joint (*lychnidis*). Unfortunately this is as far as Börner's description can be considered accurate for English material. His character " deutlich fein geknöpft " for the body hairs is not to be found in any of the British specimens of *klugkisti* which the writer has examined so far; and further, the spinal hairs of *klugkisti* are throughout not shorter than those of *lychnidis*, but both relatively and absolutely longer! Dr. Hille Ris Lambers confirms in a letter that his continental material exhibits this same discrepancy when compared with Börner's description, i.e. a negative correlation between spinal and antennal hair length. It is therefore probably as well to assume that Börner was describing atypical material of *klugkisti*, particularly as there are other good characters which render the employment of this somewhat doubtful and probably very variable feature for the identification of the species unnecessary. These are:

(1) Antennal hair length (*vide supra*); also the number of hairs on ant. III is diagnostic, there being about 6–11 in *klugkisti* and 15–20 in *lychnidis*.

(2) Dorsal sclerotization: in *klugkisti* the sclerotic area on the dorsum extends further laterally than in *lychnidis*, usually extending to ventrad the stigmata. In *lychnidis* the stigmatal plates are separate elements of the

sclerotic pattern, though they may be joined to the dorsal sclerotic area by narrow sclerotic " isthmi." The sclerotic area is also more sharply demarcated in *klugkisti*, and has a more regular outline than in *lychnidis* ; and the carapace-like nature of the more extensive sclerotic area leads to some lateral compression and elevation of the dorsum, which makes *klugkisti* a more slender insect in appearance.

(3) Shape of cauda : in *klugkisti* there is as a rule a distinct basal constriction, which makes the cauda more or less subpentagonal in outline ; in *lychnidis* such a constriction is nearly or quite absent, the cauda being nearly semicircular.

(4) Pigmentation of legs : this is less contrasted in *klugkisti* than in *lychnidis*, the shafts of the tibiae being darker and the hind femora and tibial apices paler. In some macerated specimens of *klugkisti* the legs appear almost unicolorous. As a rule the antennal apices are also paler in *klugkisti*.

Material of this species has been seen from the counties of Anglesey, Cheshire, Devon, Hertfordshire, Essex, Cambridge and Suffolk. Slides of "*lychnidis* " in the collections so far examined, including that of Theobald in the British Museum of Natural History, examined by kind permission of Mr. F. Laing, contain a very heavy preponderance of *klugkisti* over the true *lychnidis*, which in the writer's own experience is a much less common species. In their biology and living appearance both insects are very much the same, but microscopic examination is instantly conclusive as a means of identification. The antennal hair length is not quite invariably diagnostic, since I have seen at least one example of *klugkisti* having some hairs on ant. III almost equal to the diameter of the joint. Such an occurrence is, however, exceptional, and the other diagnostic characters will always serve to identify such critical specimens.

Slides of this species have been deposited in the collections of the British Museum of Natural History ; further material remains in the writer's own collection.

A table of measurements for British apterae and alatae is given below :

Apterae :

Body.	Ant.	Siph.	Cau.	Cdl. hrs.	Ap. j. rost.	Rhinaria (III and IV).	Ant. joint ratios.
2·11	1·34	0·17	0·11	6	0·17	—	21 : 15 : 9 : 6 + 33
1·62	0·66	0·10	0·08	6	0·14	—	10 : 6 : 6 : 4 + 16
1·79	0·85	0·13	0·10	8	0·15	—	(13 : 7): 6½ : 4½ + 21
Alatae :							
2·35	1·94	0·19	0·13	8	0·18	27 & 29/6 & 7	33 : 20 : 14 : 8 + 46
2·14	1·89	0·17	0·11	11	0·18	21 & 24/2 & 0	30 : 20 : 12½ : 7 + 48
2·18	1·89	0·17	0·11	13	0·18	22 & 24/5 & 4	30 : 21 : 13 : 7 + 47

The antennae are measured without joints I and II ; all lengths are in mm. Specimens 1 and 4 from Essex, 18.v.48 ; 2 from Suffolk, 20.vi.48 ; 5 and 6 from Hertfordshire, 5.vi.48 ; and 3 from Herts, 12.ix.48.

20. *Brachycaudus linariae* Stroyan, 1950.

This species was described by the writer from 14 apterae and 1 alata taken at the base of *Linaria vulgaris* at Great Wilbraham, Cambs., on 10.viii.49, attended by the ant *Lasius niger* (L.). Reference may be made to this description (Stroyan, 1950) for an account of the detailed morphology. The species is distinguished from all other species of the genus except *cardui* (L.) and *prunicola* (Kalt.) by the length of the siphunculi, which are from 2·4 to 3 times as long as the cauda and about as long as the third antennal joint; and from the two latter species by the abnormally large number of caudal hairs (10 to 13, as against 6 to 8 in *cardui* and *prunicola*), and by the breaking up of the dorsal sclerotization in the apterae. No other *Brachycaudus* is recorded from *Linaria*, and the combination of this fact with the morphological differences mentioned above should be conclusive in diagnosis of the species.

Type material in the writer's collection and the British Museum (Natural History).

21. *Anuraphis subterranea* ssp. *catonii* Hille Ris Lambers, 1935.

Originally described as *Anuraphis catonii* (Hille Ris Lambers, 1935), but subsequently regarded by the describer as a subspecies of *subterranea*, the exact status of this form is somewhat dubious. A small *Anuraphis* may be found at the bases of plants of *Pimpinella saxifraga* in July and August, which in its bright yellowish and dark green coloration appears quite distinct from the dull earthy brown apterae of *subterranea* (Walker) on *Heracleum* and *Pastinaca*. Further, an examination of the microscopic morphology reveals a marked difference in the range of number of secondary rhinaria on the antennae (more consistent in the alatae than in the apterae). Against this must be placed the fact that this difference is in just such a character as might be expected to show correlation with absolute size; and the fact that larvae of *catonii* if transferred to *Pastinaca* will feed up normally to maturity, and may show a slight darkening of colour in the process. Whether in fact we have here the beginning of a discontinuity or merely a trophic effect cannot be stated with certainty; but the writer here retains the name *catonii* in view of the apparently consistent morphological differences between the two forms.

British material of the present insect has been taken in Gloucestershire by Dr. Hille Ris Lambers, and at Trumpington and on the Fleam Dyke in Cambridgeshire by the writer.

Measurements of one aptera and one alata from material taken at Trumpington, July, 1949, are as follows:

Aptera: Body 1·81 mm., antenna without joints I and II 0·82 mm., joint ratios 17 : 7 : 6 : 5 + 16, siphunculi 0·14 mm., cauda 0·10 mm., caudal hairs 11, apical joint of rostrum 0·20 mm., 2nd joint of hind tarsi 0·11 mm., secondary rhinaria on ant. III 15 and 15, on IV 0 and 3.

Alata: Body 1·60 mm., antenna without joints I and II 0·97 mm., joint ratios 22 : 8 : 6 : 5½ + 19, siphunculi 0·13 mm., cauda 0·09 mm., caudal hairs 13, apical joint of rostrum 0·19 mm., 2nd joint of hind tarsi 0·11 mm., secondary rhinaria on III 55 and 58, on IV 13 and 12.

For comparison with these measurements similar data are given below for the two other *Anuraphis* species found in Europe. The data for *subterranea* (Walker) are from specimens collected on *Pastinaca* at Great Wilbraham, Cambs., 6.vii.49; the specimens of *farfarae* (Koch) are from *Tussilago* at Margraten, South Limburg, Holland, 28.vi.49.

(i) *Anuraphis subterranea* (Walker) sens. strict.

Aptera : Body 2·42 mm., antenna without joints I and II 1·34 mm., joint ratios 27 : 15 : 9 : 7 + 26, siphunculi 0·20 mm., cauda 0·13 mm., caudal hairs ? 12, apical joint of rostrum 0·30 mm., 2nd joint of hind tarsi 0·16 mm., secondary rhinaria on III 29 and 24, on IV 0 and 0.

Alata : Body 2·34 mm., antenna without joints I and II 1·49 mm., joint ratios 30 : 17 : 9 : 7 + 30, siphunculi 0·18 mm., cauda 0·11 mm., caudal hairs 11, apical joint of rostrum 0·27 mm., 2nd joint of hind tarsi 0·16 mm., secondary rhinaria on III 84 and 87, on IV 30 and 33.

(ii) *Anuraphis farfarae* (Koch).

Aptera : Body 2·24 mm., antenna without joints I and II 1·23 mm., joint ratios 25 : 13 : 9 : 6 + 24, siphunculi 0·24 mm., cauda 0·10 mm., caudal hairs 15, apical joint of rostrum 0·28 mm., 2nd joint of hind tarsi 0·15 mm., secondary rhinaria on III 15 and 17, on IV 0 and 0.

Alata : Body 2·61 mm., antenna without joints I and II 1·49 mm., joint ratios 33 : 16 : 10 : 6 + 28, siphunculi 0·22 mm., cauda 0·10 mm., caudal hairs 13, apical joint of rostrum 0·29 mm., 2nd joint of hind tarsi 0·14 mm., secondary rhinaria on III 75 and 76, on IV 12 and 16.

22. *Acaudinum centaureae* (Koch, 1857).

Koch in his *Die Pflanzenläuse* describes *Aphis centaureae* as having the cauda completely wanting. His statement is apparently justified until well cleared and mounted specimens are examined, when the very short and broadly rounded cauda becomes visible. This character at once serves to distinguish *Acaudinum* from all other genera of the Aphidina occurring in Britain.

Börner (1932) places *centaurae* in his new genus *Acaudinum*, which he characterizes as follows : "Ähnlich *Brachycaudus* aber Neugeborene mit 4–6 Borsten auf dem Analtergit und mit Pleuralborsten vom 2-Brust bis 5.Hinterleibstergit. Stigmen des 1.und 2.Hinterleibsringes auf einer Platte dicht nebeneinander. Schwänzchen kurz und breit. Marginaltuberkel fehlen. Ungeflügelte breit eiförmig. Ohne Wachsdrüsen. 1. Fussglied der Erwachsenen 3-borstig. Ohne Wirtswechsel an Kräutern."

In November, 1948, a slide from the Haviland Collection labelled "*Centaurea nigra* " was found to contain 2 alatae, 1 aptera and some larvae of this species. The specimens, which had passed unrecognized and were in a state which defied diagnosis, were cleared and remounted, when their identity became apparent. The locality was on Fleam Dyke, Cambridgeshire. On 26th July, 1949, in company with Dr. Hille Ris Lambers, the writer collected further material in a chalk pit a mile or two from the original locality ; and on 22nd August, 1949, it was extremely abundant on some plants of *Centaurea scabiosa* in a chalk cutting on the Guildford by-pass road where it crosses the Hog's Back in Surrey. In fact the original Haviland record was probably erroneous as to the food-plant, since the species is not known at all from *Centaurea nigra*. It is probably widespread, though very local, on chalk soils with a good growth of *C. scabiosa* ; Mr. F. H. Jacob has material including sexuales from Cambridgeshire also.

The following are some brief morphological notes to assist recognition of the species :

Apterous viviparous female : Head sclerotic ; frons very slightly and uniformly concave in outline between antennal bases, median prominence entirely wanting. Antennae black sclerotic, joint III with secondary rhinaria along whole length. Basal portion of ant. VI very short, only about one-fifth processus terminalis. Abdominal dorsum entirely membranous except for the intersegmental "' Muskelplatten " and a narrow transverse bandlike sclerite on the 8th tergite. Marginal tubercles entirely absent. Siphunculi long, slender, constricted at extreme base and tapering to apex, without any appreciable flange, imbricate as in *Aphis* L., about equal to joint III of antennae. Cauda very short and broadly rounded, rather similar in outline to that of some Lachnini, about 4 times as wide as long, with rather numerous hairs. All the body hairs, frontal and spinal hairs minute ; tibial hairs short, spiny and rather recumbent, distributed as in in *Anuraphis* Del Guercio, i.e. present practically only on the inner sides of the tibiae. Femora except at base, tarsi and apices of tibiae dark. Rostrum long, to beyond 3rd coxae, apical joint long and stout as in *Anuraphis*, about equal to joint V of antennae.

Measurements of one specimen (Fleam Dyke, 24.vi.18) : Body 2·13 mm., antennae without joints I and II 1·73 mm., siphunculi 0·48 mm., cauda 0·04 mm., antennal joint ratios 68 : 36 : 27 : 14 + 71, secondary rhinaria on ant. III 22 and 23, apical joint of rostrum 0·21 mm., 2nd joint of hind tarsi 0·14 mm., caudal hairs 15.

Alate viviparous female : As for aptera in most respects. Antennae with about 30 to 40 secondary rhinaria on joint III, spread over its whole length. Abdomen with large marginal sclerites on 2 to 4 inclusive, and one or two very small scattered scleroites across the 7th tergite.

Measurements of one specimen (Fleam Dyke, 24.vi.18) : Body 1·97 mm., antennae without joints I and II 1·58 mm., joint ratios 31 : 16 : 13 : 7 + 32, siphunculi 0·37 mm., cauda 0·04 mm., caudal hairs 13, apical joint of rostrum 0·18 mm., 2nd joint of hind tarsi 0·14 mm., secondary rhinaria on ant. III 40 and 33.

Börner's erection of a separate genus for *Acaudinum centaureae* is a very natural step ; but while there is no doubt of the generic rank of the species, it nevertheless shows many close affinities with the other members of his group *Anuraphidea*. The tibial hairs and structure of the rostrum are similar to the same features in *Anuraphis*, as has already been pointed out, and the presence of rhinaria on ant. III in the apterae also places the species close to that genus ; while the proportions of the processus terminalis and basal part of ant. VI, and the reduction to vanishing point of the marginal tubercles, shows some affinity (or perhaps convergence) with *Brachycaudus* Van der Goot. On the other hand, the frontal and siphuncular structure are entirely unlike those of any other member of the Anuraphidea, as is the entirely membranous abdominal dorsum. These three characters show a very curious parallelism with the same characters in *Metopeurum* Mordvilko. The reduction of the cauda to a small rounded rudiment in *Acaudinum* is not to be compared with anything to be found elsewhere in the whole of the Aphidina, except in apterae of *Brachycaudus rumexicolens* (Patch).

The biology of *Acaudinum* is typical for the whole of the myrmecophilous ANURAPHIDEA. The aphids are to be found living under earthen shelters at the base of clumps of *Centaurea scabiosa*, showing a preference for the thin leaf-stalks rather than the flower-stalks. They are assiduously protected by ants, which may dealate the winged forms. All the colonies seen so far by the writer have been associated with *Lasius niger* (L.). When the aphids become very abundant they may overflow from the basal shelters and appear higher up the leaf stalks.

Material of this species is deposited in the British Museum (Natural History) and in the writer's collection ; while the remounted specimens from the Haviland Collection are in the collections of the Dept. of Zoology, Downing Street, Cambridge.

23. *Sappaphis bonomii* (Hille Ris Lambers, 1935).

This species was originally described (Hille Ris Lambers, 1934) as *Yezabura bonomii*, from *Pastinaca sativa* at Trento, Italy. The species is apparently holocyclic on this host, since the males are apterous. Alatae were not found among the type material, and no further records of the species are known between 1935 and 1949. On 6th July, 1949, a mixed colony of *Sappaphis crataegi* (Kaltenbach) and *Anuraphis subterranea* (Walker) was collected on *Pastinaca sativa* at Great Wilbraham, Cambs., and when these aphids were transferred to a pot culture in the laboratory a small number of rather slender and more active *Sappaphis* was detected among the two common species. These aphids, which were easily distinguishable by their long and slender siphunculi, were identified by Dr. Hille Ris Lambers as being his *bonomii*. Not more than a dozen examples could be found in the culture, and subsequent efforts to find the species again in the field were unsuccessful; but among the specimens found were two alate viviparous females, and this form is here described for the first time. Attempts were made to start a pure culture employing six F.1 apterae, the progeny of one of the original apterae; but this proved a failure, and only three of these females were ultimately recovered for morphological examination.

The following notes on the living insects and the microscopic morphology will serve to identify the species:

Colour Notes.

All the apterae seen by the author were of a uniform pure grey colour, with very slight traces of a waxy bloom, especially on the lateral margins and ventral surface. Particularly noticeable was the complete absence in all specimens of the reddish-brown areas at the base of the siphunculi found in most species of the genus due to the underlying glandular tissue full of reddish waxy secretion.

MICROSCOPIC MORPHOLOGY.

Apterous viviparous female: Body slender, small to medium sized. Head with frons not at all sinuate, and frontal hairs minute; in some specimens rudimentary ocelli are present. Antennae of 6 segments, but IIIrd and IVth often more or less deformed at their articulation by an ankylosed fusion; length about two-thirds body length. The IIIrd joint bears tuberculate rhinaria along one side over the whole distal three-quarters of its length; the IVth bears similar rhinaria over its whole length. Vth joint very short, not much longer than the base of VI. Antennal hairs very short indeed, not more than one-quarter the diameter of the IIIrd joint. Rostrum very long, in small specimens reaching almost to the base of the siphunculi; apical joint long, about as long as IVth antennal joint. Thorax with transverse sclerotic bands on pro- and mesonotum, which may be interrupted medially; metanotum with paired spinal sclerites of fairly large size. Abdominal ornamentation consisting of paired spinal sclerites. which may enlarge to form medially interrupted bars on segments 1 to 4 inclusive, and complete spinal bars on segments 5 to 8 inclusive. Spinal tubercles are present on the vertex of the head and the 8th or 7th and 8th abdominal tergites only occasionally also on pronotum; those on the vertex are large and flat, those on abd. 8 very small. Marginal tubercles are present on the pronotum and on abd. 1 to 7 inclusive, also in many cases on the meso- and metanotum. Those on the pronotum and abdomen are very large and flat, but decrease in size progressively from abd. 1 to abd. 7. Those on the meso- and metanotum are very much smaller when they occur. Siphunculi long, slender and subcylindrical, imbricate; slightly expanded at base and constricted subapically, with a very small flange, or in smaller specimens with no apparent basal expansion. Cauda short, typical for *Sappaphis* Matsumura, with apex somewhat acute, and as a rule 5 hairs. Legs slender, fairly long, with internal tibial hairs longer than external ones, neither as long as diameter of tibia; pale except for tarsi and the apices of the tibiae and femora. All apterae so far seen may be considered to be more or less alatiform.

Measurements of specimens (Great Wilbraham, 6.vii.49 (1-5) and 2.viii.49 (6)):

	Body.	Ant.	Joint ratios.	Siph.	Cau.	Ap. jt. rost.	Rhin. L.	Rhin. R.	2 h.t.
1	1·46	0·98	20 : 9 : 5 : 4½ + 21	0·24	0·08	0·14	22/10	26/8	0·12
2	1·22	0·86	18 : 8 : 5½ : 4 + 18	0·22	0·08	0·13	16/8	18/6	0·11
3	1·44	0·90	19 : 8½ : 5 : 4½ + 19½	0·25	0·08	0·14	16/9	14/5	0·11
4	1·44	0·82	17 : 7 : 5 : 4 + 18½	0·23	0·08	0·14	19/4	(14/5)	0·11
5	1·36	0·83	19 : 10 : 6 : 5 + 12	0·24	0·08	0·14	(23/2)	17/9	0·11
6	1·78	0·77	(16 : 6) : 5 : 4 + 17	0·27	0·08	0·14	(13)	(18)	0·10

(All lengths in mm. Antennae measured without joints I and II; where rhinarial numbers or ratios of joints are bracketed the joints are so distorted as to affect the rhinarial distribution.)

Alate viviparous female: The general morphology hardly differs significantly from that of the aptera. The antennae are slightly longer and bear rather more rhinaria than those of the apterae; the IIIrd joint, however, as in the apterae, bears no rhinaria on the basal one-fifth to one-quarter of its length. The abdomen differs in its ornamentation from that of most species of *Sappaphis* in that the main central sclerotic area is broken up into its constituent transverse bars on segments 3 to 6 inclusive. This same feature occurs also in *S. palaestinensis* Hille Ris Lambers and *S. hirsutissima* (Börner), though less markedly in the latter species. The large flat marginal tubercles of the alate *bonomii* are borne on marginal sclerites. The siphunculi, cauda, rostrum and legs are as described for the apterae.

Measurements of two specimens (Great Wilbraham, 6.vii.49): (1) Body 1·44 mm., antenna without joints I and II 1·04 mm., joint ratios 22 : 10 : 6 : 5 + 22, siphunculi 0·20 mm., cauda 0·09 mm., apical joint of rostrum 0·13, 2nd joint of hind tarsi 0·12 mm., secondary rhinaria on ant. III 30 and 32, on IV 11 and 12.

(2) Body 1·50 mm., antenna without joints I and II 0·98 mm., joint ratios 22 : 10 : 6 : 5 + 18, siphunculi 0·19 mm., cauda 0·09 mm., apical joint of rostrum 0·14 mm., 2nd joint of hind tarsi 0·11 mm., secondary rhinaria on ant. III 29 and 27, on IV 10 and 13.

The relationships of this species within the genus *Sappaphis* are obscure, its morphology setting it apart from all the other western European species inhabiting Umbelliferae. The extreme uniformity of all the apterae so far known is a striking feature, since in other species with alatiform apterae the degree of development of the ocelli and rhinaria and the abdominal ornamentation show a wide range of variation from the completely alatiform to the completely apteriform. The narrow range of variation in the present species suggests a stability due to a fine adjustment to its environment over a long period of time. This would indicate *bonomii* as one of the older species of the genus, and would probably account for its wide morphological differences from the other members of *Sappaphis*.

Material of *bonomii* is in the collection of the writer.

24. *Sappaphis choerophylli* (Börner, 1940).

This species was first described by Börner in his self-published paper of 1940. As has been pointed out by Hille Ris Lambers, although the descriptions in this paper keep just within the limits of nomenclatural validity, many of them are so inadequate as to be practically *nomina nuda* ; the present species is a case in point, since the description is completely useless for the recognition of the species apart from its reference to the host-plant.

No further record of a *Sappaphis* from *Choerophyllum* was forthcoming until 6th July, 1949, when the writer discovered colonies of *Sappaphis* on the root collars of *Choerophyllum temulum* in the same locality in the parish of Great Wilbraham, Cambs., where *S. bonomii* occurred. The present species, which Dr. Hille Ris Lambers agrees must be regarded as being Börner's *choerophylli*, was attended by *Lasius niger* (L.), and occurred rather more below the surface than most *Sappaphis* species ; no appreciable signs of basal shelters were to be seen, and in this respect the species resembled some colonies of *S. hirsutissima* (Börner) found in association with *L. umbratus* and *mixtus*. This rather cryptic habit may account for the absence of records of the species.

In view of the complete uselessness of the original description a fresh account of the species is given here.

Colour Notes.

The apterae vary in colour from ochreous grey to a dull pinkish grey or terra-cotta hue ; the older apterae have a rather plentiful wax powdering which is of a blue-grey tinge. This superimposed on the body colour gives the older specimens something of a purplish-grey colour. Parasitized individuals, which were much in evidence, were of a pale yellow colour, slightly mottled with pinkish, and almost without wax-powdering. The young individuals are pale ochreous or pinkish to putty-coloured. The alatae have the abdomen of a dull pinkish colour, powdered ventrally with wax.

MICROSCOPIC MORPHOLOGY.

Apterous viviparous female : Body oval, small to fairly large. Frons somewhat sinuate owing to median convexity and low antennal prominences. Vertex with a pair of fairly large tubercles. Antennae typical for *Sappaphis*, from about two-fifths to more than half body length, proportionately longer in alatiform apterae. Some alatiform specimens with traces of ocelli. All cephalic and antennal hairs very long, fine and acute at apices ; antennal hairs erect, those on III up to more than three times the articular diameter of the joint in length. Alatiforms may occasionally bear a few rhinaria on the apical portion of III and on IV ; in such forms the antennae are much darker than in the typical apterae, particularly towards the apices. Pronotum with a complete sclerotic band and a pair of large, flat marginal tubercles, occasionally also with a pair of spinal tubercles. Meso- and metanotum each with a pair of large lateral sclerites bearing the long, acute marginal hairs, and with small hair-bearing scleroites scattered across the spinal region and forming a more or less broken-up transverse band across each segment ; tubercles are absent from both these segments. Abdominal dorsum with a well-marked sclerotic ornamentation with a wide range of variation between the typical apterae and the more extreme alatiform examples. The typical apterae, which were not common in the sample under consideration, have very small paired spinal scleroites on segments 1 to 5 inclusive, median transverse bars on 6 to 8 inclusive, and very small marginal scleroites immediately surrounding the anterior border of the marginal tubercles on the first three or four segments. In nearly all the specimens under discussion there is more or less of an enlargement of the sclerotic areas on the anterior segments, leading to the formation of more or less broken-up transverse bars on most or all of the first four segments and of a complete bar on 5. In extreme examples the bars on 3 to 6 become complete and more or less fuse together, forming a central sclerotic area similar to that of alatae. In such specimens the marginal sclerites are also large as in the alatae. Marginal tubercles, which are rather flat, are present from segments 1 to 5 inclusive, and usually on 7; spinal tubercles as a rule only on 8, but sometimes also on 7. Pleural intersegmental " Muskelplatten " well developed. The dorsal hairs are extremely numerous, and arranged in two rather irregular transverse rows on each segment. It is not possible to recognize or delimit the normal series of spinal, pleural or marginal hairs, since each transverse row may consist of up to 24 or 25 hairs. All the hairs are long, acute and erect, the marginal hairs being up to twice as long as the diameter of the marginal tubercles. Siphunculi of moderate length, slightly tapering from base to apex, constricted at apex by a small circumcision, and with a distinct flange; imbricated throughout length. Cauda normal, typically with 8 or 9 hairs. Rostrum reaching to about third coxae; apical joint fairly stout and a little longer than 2nd joint of hind tarsi. Legs normal, somewhat sclerotic throughout, darker at apices of tibiae; tibial hairs rather long, fine, acute and outstanding, those on hind tibiae about as long as, or a little longer than, the greatest diameter of the tibia. In some specimens the dorsal body cuticle exhibits a rather distinct reticulation.

Measurements of specimens (Great Wilbraham, 6.vii.49):

Body.	Ant.	Joint ratios.	Siph.	Cauda.	Caud. hrs.	Ap. jt. rost.	2nd jt. hd. tar.	Dorsal sclerⁿ.
1·98	1·04	22 : 12 : 7 : 5 + 20	0·21	0·08	9	0·16	0·13	Normal.
1·89	1·10	22½ : 12 : 8 : 5 + 20	0·20	0·09	8	0·15	0·13	Altfm. +
2·38	1·34	29 : 15 : 11 : 6 + 23	0·24	0·11	8	0·17	0·14	,, ++
2·21	1·33	28 : 15½ : 10½ : 6 + 22	0·26	?	9	0·16	0·14	,, ++
1·78	0·88	16 : 9 : 7 : 5½ + 17	0·19	0·09	9	0·16	0·13	Normal.
1·73	0·93	19 : 10 : 7 : 5½ + 16	0·18	?0·10	8	0·14	0·11	,,

(All measurements of length in mm.; antennae measured without joints I and II. " Altfm. + or ++ " indicates a greater or less degree of development of the alatiform sclerotic pattern.)

Alate viviparous female: Characters much as for aptera in respect of chaetotaxy, arrangement of tubercles and structure of siphunculi and cauda. Antennae black sclerotic, about three-fifths body length; hairs long and acute, but somewhat shorter and less outstanding than those of apterae, not more than about twice the articular diameter on the IIIrd joint. Secondary rhinaria not very protuberant, distributed densely along whole length of III and IV; usually absent on V, but up to 4 may be found on this joint in a number of examples. Abdominal ornamentation heavily developed, consisting of (*a*) marginal sclerites on 1 to 7 inclusive, small on 1, large on 2 to 5, those on 6 and 7 fused with the extremities of the transverse bars across those segments; (*b*) narrow, more or less broken-up transverse bands on 1 and 2, often extending right up to the marginal sclerites; (*c*) a large solid area of sclerotization extending over the whole spinal area of segments 3 to 5 inclusive, and usually including the intersegmental " Muskelplatten " of 3/4 and 4/5; (*d*) complete transverse bars across segments 6 to 8 inclusive; that on 6 is fused medially with the central sclerotic area except for a small central membranous patch on the 5/6 intersegment, and fused marginally with the band on 7 (this fused marginal portion representing the marginal sclerites of 6 and 7; *vide supra*). The marginal and spinal tubercles of the abdomen are smaller in the alatae than in the apterae, the spinal tubercles particularly being very small, with one of the pair sometimes absent. Only rarely is there a spinal tubercle on 7, and a complete pair on this segment has not yet been observed. Legs sclerotic, the shafts of the tibiae except at apices somewhat paler than the rest of the legs. Wings normal.

Measurements of specimens (Great Wilbraham, 6.vii.49):

(1) Body 2·21 mm., antenna without joints I and II 1·33 mm., joint ratios 30 : 14½ : 10 : 6½ + 22, siphunculi 0·19 mm., cauda 0·10 mm., caudal hairs 8, apical joint of rostrum 0·16 mm., 2nd joint of hind tarsi 0·14 mm., secondary rhinaria on ant. III 62 and 63, on IV 19 and 19, on V 0 and 0.

(2) Body 1·79 mm., antenna without joints I and II 1·28 mm., joint ratios 28 : 15 : 9½ : 6 + 21½, siphunculi 0·18 mm., cauda 0·10 mm., caudal hairs 5, apical joint of rostrum 0·14 mm., 2nd joint of hind tarsi 0·13 mm., secondary rhinaria on ant. III 64 and 63, on IV 20 and 19, on V 0 and 0.

The affinities of *S. choerophylli* are closest with the next species to be described, *S. hirsutissima* (Börner), which it resembles in a number of morphological features. Both species show an abnormal development of the chaetotaxy, the hairs being very long, fine and erect; and the abdominal, crural and antennal hairs particularly are very much more numerous than in other species of the genus. The present species shows these features to a lesser degree than *hirsutissima*, since a regular arrangement of the dorsal abdominal hairs can still be detected, and the antennal and tibial hairs are less numerous than in that species. Apart from this and from the possession of rather longer siphunculi the apterae bear a very strong superficial likeness to those of *hirsutissima*; the apical structure of the siphunculi and the irregular outline of the dorsal abdominal sclerites are further points of resemblance between the two species. The alatae are much less similar than the apterae, those of *choerophylli* having less tuberculate rhinaria, fewer and less erect antennal hairs and a much more solid central sclerotic area on the abdominal dorsum than *hirsutissima*. The close relationship of the host-plants of the two species is further cause for believing that *choerophylli* and *hirsutissima* form a valid group within the genus.

25. *Sappaphis hirsutissima* (Börner, 1940).

This species was also first described by Börner in his self-published paper of 1940, and like *S. choerophylli*, rather inadequately so. He distinguishes the species from *choerophylli* by the possession of marginal tubercles on the metathorax as well as on the first to fifth and seventh abdominal segments. It is doubtful whether this is a completely reliable character, since the presence or absence of such tubercles on the meso- and metathorax is very variable in *Sappaphis*.

S. hirsutissima spends its whole life cycle on the basal parts of *Anthriscus sylvestris*. It appears to be widely distributed, and is probably extremely common where its host-plant occurs in quantity. The most important requirement of the species appears to be a well-drained soil; the writer has found it in friable sandy loam, in alluvium forming a bank against the parapet of a river bridge and in well-drained banks of calcareous boulder clay, but never on *Anthriscus* in ditches or low-lying damp meadows, even where colonies were to be found in drier situations a few yards away. This preference may be an idiosyncrasy of the ants which protect the species; in this country the writer has so far only found the aphids with *Myrmica* spp. and with *Lasius mixtus* or *mixto-umbratus*. In the former case the ants build a basal shelter which readily reveals the presence of the aphids; in the latter case the colonies live quite concealed below ground-level on the taproots. Dr. Hille Ris Lambers and the writer found the species once with *Lasius niger* in Holland, but in this instance the *Sappaphis* were mixed with *Aphis podagrariae* Schrank and were very few in number; and Dr. Lambers wrote later in a letter that *Lasius niger* in his garden had refused to accept these *hirsutissima*, though this of course may have been due to an alien nest-odour on the aphids.

British material has been examined from the following places: Woburn, Beds, and Spalding, Lincs (trapped alatae, *J. P. Doncaster*); Harpenden, Herts., and Reading, Berks. (*V. F. Eastop*); Little Chishill, Essex, and Great Wilbraham, Hauxton Mill, Newton and Kennet in Cambridgeshire, and Barkway, Herts. (*H. L. G. Stroyan*).

The following descriptive notes will enable the species to be recognized.

Colour Notes.

S. hirsutissima may be readily distinguished in the field from all the other British species of *Sappaphis* by the very distinct blue-green colour of the apterae and immature forms. The early generations are much darker than the late summer forms, but even in these latter the colour is of a distinctly blue-green tint. This character serves to distinguish the species from *S.* "*communis* (Mordvilko)" of Börner, which also occurs on *Anthriscus* from about midsummer onwards, sometimes forming mixed colonies with *hirsutissima*; "*communis*" varies from pinkish-grey to greyish-green, but never displays the bluish tinge of *hirsutissima*.

MICROSCOPIC MORPHOLOGY.

Fundatrix: Body very stout and broad oval. Head, antennae, legs and siphunculi dark sclerotic, and with entire sclerotic bands across pro-mesonotum. Antennae 6-jointed, but frequently with incipient fusion of III and IV; specimens probably also occur with 5-jointed antennae, but these have not yet been seen. Frontal and antennal hairs very long, fine and acute, those on antennae completely erect; the hairs on ant. III up to three-and-a-half times the articular diameter of the joint, or about 0·08 mm. long. In one specimen examined joint IV has 2 small secondary rhinaria near the apex in the right antenna. Processus terminalis somewhat less than twice the basal portion of VI. Metanotum with a more or less broken-up band of irregular scleroites. Abdominal dorsum with more or less paired scattered spinal scleroites on 1 to 5 inclusive; an irregularly-shaped bar composed of fused scleroites on 6 occupies from one-half to the whole distance between the bases of the siphunculi; there are complete transverse bars on 7 and 8. The spinal tubercles are very small and occur on the head and abd. 7 and 8 only. Marginal tubercles on all segments from the pronotum to abd. 7 inclusive; those on pronotum very large and flat, the remainder decreasing in size posteriorly, those on 7 being only equal to, or up to twice the size of, the spinal ones. Whole body clothed with very numerous long, acute, erect hairs; apart from a certain transverse regularity no seriation of the dorsal abdominal hairs is apparent. The marginal hairs are about equal in length to the diameter of the pronotal tubercles, or about 0·08 mm. Siphunculi very short, about one-nineteenth to one-sixteenth body length, markedly imbricate, constricted subapically and with a marked flange. Cauda typical for *Sappaphis*, about four-fifths to seven-eighths siphunculi, with 6 to 8 hairs. Rostrum to just beyond 2nd or nearly to 3rd coxae; apical joint about equal to or slightly longer than siphunculi. Second joint of hind tarsi about six-sevenths to nine-tenths apical joint of rostrum.

Measurements of one specimen (Hauxton Mill, Cambs., 12.v.49): Body 2·82 mm., antenna without joints I and II 1·20 mm., joint ratios 26 : 12 : 13 : 8 + 15, siphunculi 0·16 mm., cauda 0·13 mm., caudal hairs 8, apical joint of rostrum 0·176 mm., 2nd joint of hind tarsi 0·144 mm., secondary rhinaria on ant. III 0 and 0, on IV 0 and 2.

Apterous viviparous female : Body more slender than in fundatrix, and average size rather smaller, particularly towards the end of the summer ; some first-generation fundatrigeniae are intermediate between typical apterae and fundatrices, but these can be recognized by the longer processus terminalis, which is always more than twice as long as the base of the VIth joint. Apart from this, and the more slender form with longer legs and antennae, the morphology of the typical aptera is similar to that of the fundatrix ; the marginal tubercles may be variably absent from abd. 6 or 7 on one or both sides, and one or more of the spinal tubercles may also be missing from 7 or 8. The body hairs also appear more closely set owing to the smaller size of the insects. In the first generation of fundatrigeniae many alatiform apterae occur ; in these the abdominal sclerotic pattern is increased to a varying degree, forming transverse bands across the more anterior abdominal segments, and small somewhat protuberant secondary rhinaria are present in many cases ; the distribution of these is typical, appearing in the majority of examples only on the apical half of IV, but in extreme cases all along IV and at the apex of III. A very few of the alatiforms show slight traces of ocelli, and occasionally small spinal tubercles are present on the pronotum.

Measurements of specimens :

Body.	Ant.	Joint ratios.	Siph.	Cauda.	Caud. hrs.	Ap. jt. rost.	2nd jt. hd. tar.	Dorsal sclern.
2·24	1·12	22 : 14 : 10 : 7 + 17	0·14	0·11	7	0·18	0·14	Normal.
2·34	1·26	26 : 16 : 12 : 6½ + 18	0·16	0·11	?8	0·18	0·14	Alatiform.
2·30	1·23	27 : 16 : 11 : 7 + 16	0·16	0·13	7	0·18	0·14	,,
1·76	0·77	15 : 8 : 7 : 5 + 13	0·10	0·08	6	0·14	0·11	Normal.
1·44	0·78	16 : 8 : 7 : 5 + 13	0·10	0·09	6	0·16	0·11	,,
2·08	0·94	19 : 11 : 9 : 6 + 14	0·14	0·10	8	0·17	0·13	,,

The first three specimens measured from Hauxton Mill, 12.v.49 ; the fourth and fifth from Great Wilbraham, 16.viii.49 ; the sixth from Harpenden, 29.ix.48. All lengths in mm. ; the antennae measured without joints I and II. Nos. 2 and 3 have secondary rhinaria as follows : (2) 0/4, 0/6, (3) 0/6, 0/3.

Alate viviparous female : The number and arrangement of the antennal, cephalic, crural and body hairs is very much as in the apterae, i.e. very long and acute, numerous and completely erect ; the length of those on abd. III is up to 0·05 mm. The abdominal ornamentation is rather similar to that described by Hille Ris Lambers for *S. palaestinensis* H.R.L., the mid-dorsal sclerotic area being more or less broken up along the intersegments into its constituent bars. Siphunculi very short, from barely as long as cauda to about one-and-a-half times as long, and shorter than the apical joint of the rostrum ; subcylindrical, slightly imbricate and with a moderate flange. Marginal tubercles on abdomen from 1 to 7 inclusive, those on 6 frequently missing ; spinal tubercles on vertex, occasionally on pronotum and on abdomen 8 ; an odd tubercle is fairly frequent on 7, but a complete pair very rare. The rhinaria on the antennae are very much more tuberculate than in *S. choerophylli,* and occur along joints III to V inclusive ; the erect hairs arising from between these very tuberculate rhinaria give the antennae a very characteristic and curious appearance. It is possible that the late summer alatae of *hirsutissima* may bear a closer resemblance to those of *choerophylli* than is here indicated ; a tendency to breaking up of the abdominal ornamentation may be seen in spring alatae of *S. crataegi* (Kalt.) also, and this feature may not be present in later generations of *hirsutissima* ; while the presence or absence of rhinaria on joint V of the antennae is also a character showing a certain amount of variation in different generations of some species of *Sappaphis.* However, the tuberculate rhinaria, erect antennal hairs and more numerous and irregularly disposed body hairs will always serve to identify *hirsutissima* when compared with *choeropyhlli.*

Measurements of specimens :

		Joint ratios	Rhin. L.	Rhin. R.			Ap. jt.	2nd jt.
Body.	Ant.	(III : IV : V :VIb+pt.).	(secondary only).		Siph.	Cau.	rost.	h. tar.
2·19	1·65	37 : 22 : 14 : 8 +22	60/35/8	67/30/4	0·12	0·11	0·16	0·14
2·10	1·58	35 : 22 : 14 : 7 + 21	55/30/8	59/35/8	0·13	0·11	0·14	0·14
2·22	1·54	35 : 20 : 13 : 7½ + 21	53/26/2	52/19/3	0·14	0·11	0·17	0·14

All length measurements in mm. ; antennae measured without joints I and II. The specimens all bred in laboratory from nymphs collected at Hauxton Mill, Cambs, 12.v.49.

Oviparous female (*from two specimens*) : Slightly smaller than normal apterae ; abdomen with dorsum completely without sclerotic pattern except for very small scattered scleroites across 7 and a narrow band across 8, and small broken scleroites round the anterior margin of the marginal tubercles on first three segments. " Muskelplatten " very small and inconspicuous. Spinal tubercles only on vertex of head and abdomen 8, very small on the latter segment. Marginal tubercles may be present on all segments from pronotum to abdomen 7 inclusive, or absent from one or more intermediate segments ; rather smaller than those of apterous viviparous female. Body hairs and hairs on legs and antennae as in viviparae. Hind tibiae hardly at all swollen, with only about two pseudosensoria on basal 1/3, even these sometimes absent.

Measurements of one specimen : Body 1·97 mm., antenna without joints I and II 0·80 mm., joint ratios 14 : 8½ : 8 : 5½ : + 14, siphunculi 0·11 mm., cauda 0·10 mm., caudal hairs 8, apical joint of rostrum 0·16 mm., 2nd joint of hind tarsus 0·13 mm., pseudosensoria on hind tibiae 2 and 1. (Harpenden, Herts., 29.ix.48, *V. F. Eastop*.)

26. *Sappaphis lauberti* (Börner, 1940).

Originally described (Börner, 1940) as *Yezabura lauberti*, this species forms one of a trio which, though readily distinguishable in the field by their biology, show so much intergrading of morphological characters that it has so far proved impossible to key them in such a way as to provide a safe diagnosis for single specimens. The other members of this trio are *Sappaphis angelicae* (Koch), which lives without heteroecy on *Angelica sylvestris*, and *S. communis* (Mordvilko) in the sense of Börner (1932), which is found in midsummer in the leaf bases of *Anthriscus sylvestris*, sometimes in mixed colonies with *S. hirsutissima*.[1] Whether or not this latter species is in fact the alternate host form of *communis* Mordvilko is not certain at present, and the status of *communis* as a British species will therefore be left for discussion in a future paper on the species of *Sappaphis* Matsumura. For the purposes of the present account, however, the morphology of the British material of " *communis* " will be considered in relation to that of the other two forms of the complex, in order to provide data for the identification of the species.

Sappaphis lauberti may be found in plenty during the months from May to September, forming colonies in the sheathing leaf-bases of *Heracleum sphondyleum*, which are tented over by the ants which habitually attend the species. Up to the present no fundatrices have been found, the first forms to appear being (in the writer's experience) alatae, which may be found singly in the leaf bases from about the last fortnight in May to the middle of June. This would appear to suggest heteroecy, a suggestion strengthened by the fact that gynoparae can with ease be transferred in the autumn to apple (though not to hawthorn), and give birth there to oviparae which can feed up and become mature. However, this is not final proof of heteroecy, since the species of this genus have a general tendency to accept apple or hawthorn in the autumn, whether or not they can develop on these hosts in the spring. This would appear to be an evolutionary relic of their original heteroecious condition, and in the case of *lauberti* would indicate that the species was derived from the apple-inhabiting group of the genus rather than the *Crataegus*-group, a conclusion borne out by the morphology.[1] However, no primary host forms have yet been recorded which would agree with *lauberti*, and this in the case of so common a species is strong presumptive evidence against heteroecy from apple to *Heracleum* in nature. It is possible that a careful search low down on the tap-roots of *Heracleum* in early spring may reveal the habitat of the fundatrices, since *hirsutissima* has been found occurring in April about 2 in. below ground level on the roots of *Anthriscus*, and the same habit may be common to a number of the myrmecophilous monoecious species of the genus.

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[1] Borner (1950) has now renamed his " *communis* Mordv." *anthrisci* n.n.

Theobald's (1927) *Anuraphis heraclei* Koch is a synonym of *lauberti* and not *Sappaphis crataegi* (Kaltenbach), as was suggested by Hille Ris Lambers writing before the description of *lauberti*.

The following brief morphological and colour notes are taken from material of *lauberti*, *angelicae* and " *communis* " in the writer's possession. No attempt is made to provide a morphological key to the three forms, since such keys will always break down in some few individual cases; but where characters of statistical validity exist to separate the species these are indicated, and these taken in conjunction with the host plant records should serve for the identification of any sample.

Colour Notes.

Apterae varying from pinkish grey through pale grey to mottled grey-green; all three species covered with a greyish-white mealy pulverulence, that of *angelicae* being in mature specimens somewhat denser as a rule than that of the other two. Alatae pinkish grey to grey or buff with the usual black sclerotic pattern; winged nymphs pinkish.

Microscopic Morphology.

Apterous viviparous female : All three species show the typical *Sappaphis* morphology. The frontal, body and antennal hairs in all three are fairly long and acute, but show no undue multiplication in number; however, the marginal hairs on the abdomen in *lauberti* and " *communis* " tend to be more numerous than in *angelicae*, and the 8th tergite in these species shows a frequent departure from the number of four hairs which is typical of *angelicae*. Antennal hairs from almost recumbent to erect; on ant. III they are from about 14 to 20 in number, and up to twice the articular diameter of the joint in length (very slightly longer on the average in *lauberti* and " *communis* " than in *angelicae*). Abdominal hairs all long and acute, about as long as frontal and antennal hairs; marginal hairs erect and much longer than the diameter of the marginal tubercles. Sclerotic pattern, except in alatiform individuals, very constant, consisting of the usual transverse bars on abd. 6 to 8 inclusive, and small paired spinal scleroites bearing spinal hairs on the anterior abdominal segments; intersegmental " Muskelplatten " fairly well developed. The chief variation is an increase in number and tendency to coalesce of the spinal scleroites on the anterior srgments. Spinal tubercles present on vertex and on abd. 8, 7–8 or 6–8. Marginal tubercles on pronotum and abd. 1–5 inclusive in all three species; on abd. 7 they are present in practically all specimens of "*communis*" from *Anthriscus*, complete pairs being present in about 94 per cent.; only about 20 per cent. of *lauberti* apterae have such tubercles on 7, pairs being present in less than 5 per cent. of those examined by the writer; while in *angelicae* they are almost invariably absent, less than 1 per cent. showing even a single one on 7. Siphunculi of moderate length, slightly tapering, sclerotic and imbricate in all three species, with a small flange. Cauda, rostrum and legs normal. Alatiform specimens are fairly frequent in late summer and autumn generations; in these the development of rhinaria occurs progressively from the apices of the antennal joints proximad, and from the apex of IV basad when the antenna is taken as a whole. The alatiforms when fairly extreme in type usually have somewhat shorter antennal hairs than the normal apterae, thus conforming to the alate type.

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[1] Börner (1950), in a paper just received by the author, places both *lauberti* and *angelicae* with *crataegi* and *ranunculi* (both of which he also drastically subdivides) as species heteroecious from *Crataegus*. He gives no evidence in support of this, and without such evidence his statement carries little conviction; it is quoted here to indicate the need for further work on the biology of *Sappaphis* species.

Measurements of specimens:

Body.	Ant.	Joint ratios.	Siph.	Cau.	C.h.	Ajr.	2ht.	Hl./III.	
2·22	0·95	20 : 10 : 8 : 5½ + 16	0·22	0·11	5	0·18	0·14	0·048	*lauberti.*
2·22	1·25	25 : 15 : 9 : 6 + 23	0·24	0·11	6	0·18	0·14	0·052	
1·98	0·90	17 : 10 : 6 : 5 + 18	0·19	0·10	5	0·18	0·13	0·032	
1·84	0·82	14 : 8 : 7 : 5 + 17	0·18	0·08	5	0·16	0·11	0·029	*angelicae.*
2·16	1·02	22 : 11½ : 7½ : 6 + 17	0·21	0·11	5	0·18	0·13	0·048	
1·92	0·90	16 : 9 : 9 : 5½ + 18	0·21	0·10	5	0·17	0·13	0·042	"*communis.*"

The above specimens are from Essex, Herts., and Cambs.; Cambs. and Surrey; and Cambs. respectively. All measurements of length in mm.; antennae measured without joints I and II; Ajr. = apical joint of rostrum, 2ht. = 2nd joint of hind tarsus, Hl./III. = length of longest measurable hair on ant. III.

Alate viviparous female: All three species with typical *Sappaphis* facies. Hairs longish and acute, though not quite so long as in the apterae, and those on antennae semi-recumbent. Antennae fairly slender; in *lauberti* with secondary rhinaria along whole length of III and IV, but only rarely 2 or 3 on V; in *angelicae* with rhinaria generally on III to V inclusive, the number on V varying from about 3 to 13, only rarely none on V; in "*communis*" the writer's only alate specimen has 4 rhinaria on one Vth joint and none on the other; on the other hand, three alatae from apple collected by Mr. J. P. Rogerson in Cumberland in 1945, and which may possibly represent the true *communis* of Mordvilko, have very many more rhinaria on III and IV than the *Anthriscus* specimen, and the only one with joint V present in both antennae has 8 and 10 on this joint on the two sides respectively. In *lauberti* and *angelicae*, and also in alatae of "*communis*" described by Dr. Hille Ris Lambers in a letter to the writer, the sclerotic area of the abdominal dorsum is very large and extensive and solidly pigmented, extending laterally almost to meet the marginal sclerites on 3 to 5 inclusive, and obliterating the intersegmental "Muskelplatten"; the bars on 6 and 7 are also very wide, and usually fuse with each other laterally; that on 6 also fuses partially with the posterior margin of the central sclerotic area. However, the writer's specimen of "*communis*" has a much less extensive central shield than that described by Dr. Lambers, and reduction thus evidently occurs in some cases. Spinal and marginal tubercles distributed much as in apterae, but the marginal tubercles on 7 are less frequently developed in *lauberti*, i.e. a single tubercle is present in less than 5 per cent. (and in none of Dr. Hille Ris Lambers' material), and paired tubercles never; in *angelicae* a single alata out of 46 in the writer's possession has one tubercle, a percentage comparable with that of the apterae; in "*communis*" the writer's and Dr. Lambers' alatae all have tubercles on 7, either paired or single. Siphunculi fairly long and slender, blackish sclerotic, slightly tapering to apex and with a very narrow flange. Legs slender, rather long, entirely black except for extreme base of femora. Other characters as in apterae.

Measurements of specimens :

Body.	Ant.	Joint ratios.	Siph.	Cau.	C.h.	Ajr.	2ht.	Rhinaria. III.	Rhinaria. IV.	Rhinaria. V.
2·11	1·45	28 : 17 : 12 : 6½ + 27	0·18	0·10	4	0·14	0·14	63/67	31/24	1/0
2·34	1·39	31 : 15 : 11 : 7 + 23	0·22	0·12	10	0·18	0·14	71/63	20/20	0/0
2·08	1·50	33 : 16 : 10 : 6½ + 28	0·19	0·11	5	0·17	0·14	77/81	27/25	0/0
2·05	1·64	34 : 18 : 12 : 7½ + 31	0·22	0·11	5	0·16	0·13	68/77	30/30	13/8
2·06	1·42	32 : 17 : 12½ : 7 + 30	0·21	0·10	5	0·16	0·14	81/78	28/29	7/12
1·81	1·17	24 : 13 : 10 : 6 + 20	0·14	0·10	4	0·15	0·11	58/59	18/24	0/4

Of the above specimens, Nos. 1 to 3 are *lauberti* from Herts., Essex and Cambs. respectively ; Nos. 4 and 5 are *angelicae* from the Netherlands and Surrey respectively ; and No. 6 is " *communis* " from Cambs. No. 1 is of the spring migrant generation, Nos. 2, 4 and 6 of the midsummer alate generation, and Nos. 3 and 5 are gynoparae. All measurements and abbreviations as in table given for apterae.

Material of the forms described here has been deposited in the collections of the British Museum of Natural History ; and further material remains in the author's collection.

27. *Nasonovia pilosellae* Börner, 1933.

This aphid, together with *N. nigra* (Hille Ris Lambers) (*Myzus hieracii* Kaltenbach of Theobald, nec *Aphis hieracii* Schrank, 1801) belongs to a small group of non-migrating species of *Nasonovia* which, in the alate forms at least, are very hard to distinguish with certainty from *ribis-nigri* (Mosley). They are characterized by the possession of a normal 1st tarsal joint chaetotaxy of 3.3.2 as against the normal 3.3.3 of *ribis-nigri*, and as a rule by the possession of fewer rhinaria on the third antennal joint in the apterae and by a greater tendency to sclerotization of the abdominal dorsum in this form. None of these characters are completely stable, however, the most nearly infallible being the tarsal chaetotaxy, since very few specimens show the reversion to 3.3.3 on both hind tarsi, though a few have it on one.

The present species is holocyclic on *Hieracium pilosella*. Probably owing to confusion with *ribis-nigri* there are very few records of it in Britain, but it is probably very common, and may be looked for wherever the host plant is abundant. The fundatrices cause a very typical tight cigar-like rolling of the rosette leaves of the plant in early summer ; the fundatrigeniae leave the gall very early, so that the examination of the galls is not usually a very profitable method of collecting the species. The later generations occur up the flower-stems and on the inflorescences, and are then more conspicuous, the apterae being of a rather shiny dark reddish or brownish-green colour.

The writer has apterae of *pilosellae* from *Hieracium pilosella* at Newsells, near Royston, Herts., in August, 1948 ; and Mr. A. W. Colling has material from the closely related *H. aurantiacum* at Bangor, Caerns.

Measurements of one aptera (Newsells, viii.48) : Body 1·76 mm., antenna without joints I and II 1·47 mm., joint ratios 24 : 15 : 14 : 5 + 34, siphunculi 0·30 mm., cauda 0·21 mm., caudal hairs 7, apical joint of rostrum 0·16 mm., 2nd joint of hind tarsi 0·10 mm., secondary rhinaria on ant. III 8 and 8.

Note.—A third species apparently belonging to this small group of non-migrating *Nasonovias* is *Aphis* (*sic*) *compositellae* Theobald. Through the courtesy of Mr. Frederick Laing I have had an opportunity to examine the type material of this species, and found it to be closely allied to *N. nigra* Hille Ris Lambers from *Hieracium murorum*. It differs from the latter species in the proportions of the antennal joints and the siphunculi. Theobald's material is a mixture of this *Nasonovia* and a *Brachycaudus* species, and his figures of the insect (Theobald, 1927) also seem to be composite; but the *Brachycaudus* is not represented in the type slides, so that no doubt exists as to the proper application of the name. *N. compositellae* does not appear ever to have been re-found since the original records of C. L. Walton. A possible fourth species, as yet undescribed, is represented by a single alata among trapped material belonging to Dr. J. P. Doncaster, which is remarkable in having a solid sclerotic area like that of a *Myzus* or *Brachycaudus* species, from the 3rd to the 6th abdominal segment inclusive. In other respects the specimen is a typical member of the genus *Nasonovia*.

It will be noted that in the present account the position of the genus *Nasonovia* Mordvilko is not that assigned to it in the Kloet and Hincks Check-list. This is because a consideration of the generic characters lead to the conclusion that *Nasonovia* is most closely related in the morphological sense to *Brachycaudus* Van der Goot on the one hand and to *Hyperomyzus* Börner on the other; and it is therefore probably more suitable to treat these genera in proximity to the group Anuraphidea of Börner.

28. *Cavariella archangelicae* (Scopoli, 1763).

Thomas and Jacob (1940) refer to "a new species (of *Cavariella*) with a number of sensoria on the 4th segment of the antennae in al. viv. ♀♀" taken by Dr. Thomas at Pwllheli, Caerns., on *Salix viminalis*, 20.vi.38. This species, new to Britain but not to science, was in fact *C. archangelicae* Scopoli, migrating from *Salix* to *Angelica* spp. Hille Ris Lambers (1947*a*) gives a key to the determination of the European species of *Cavariella* Del Guercio based on the antennal and siphuncular proportions. *C. archangelicae* is to be distinguished according to this key by the following combination of characters; siphunculi somewhat swollen and more than twice as long as cauda; the processus terminalis from $1\frac{1}{2}$ to 2 times as long as base of VIth antennal joint; secondary rhinaria on IVth joint of antenna in alatae from 8 to 16 in number. This combination of characters is not found in any other species.

No subsequent records of the species are in the writer's possession at the present time. The material referred to above is in the collection of Dr. I. Thomas.

29. *Cavahyalopterus noxius* (Mordvilko, 1914 ?[1]).[2] [illegible]

Brachycolus noxius Mordvilko (Grossheim, 1914).
Cavahyalopterus graminearum Mimeur, 1942.

This very distinctive species, known as an occasional pest of barley in Russia, and described as a new species from North Africa by Mimeur (1942), is known as a British insect only from an alate female trapped at Baston, Derbyshire,

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[1] The date of first publication of the name *noxius* Mordvilko is uncertain. Dr. Hille Ris Lambers (*in litt.*) says the paper by Grossheim (1914) on *Brachycolus noxius* is the earliest reference he has been able to trace, so that this date is the one provisionally used here.

[2] *See* Corrigendum on p. 124.

3.vii.46 (*L. Broadbent*).[3] It is known also to occur in Holland (Dr. Hille Ris Lambers thrashed two or three specimens from grass along a ditch near Bennekom, Gelderland, while the writer was collecting with him in June, 1949), and probably it occurs sparingly in suitable spots all over Europe.

The following morphological notes were made from Dr. Broadbent's trapped alata :

General form elongate as in *Hyalopterus* Koch. Head without evident antennal tubercles. Frontal hairs moderate, slender, curved. Antennae short, of six segments ; 5 somewhat small, protruding secondary rhinaria in a single row on III, and 2 on IV. Abdomen with lateral sclerites on 2 to 4 inclusive, these (on 3 and 4 at least) bearing small marginal tubercles about as large as the spiracles, which are oval and not appreciably reniform. Siphunculi very short, truncate conical or half-barrel shaped, with hardly any flange. Cauda long as in *Hyalopterus*, with 7 hairs. There is a very marked finger-shaped supracaudal process similar to that seen in the apterae of *Cavareilla* Del G., and bearing two curved hairs just before the apex. Median vein of fore wing twice forked. Antennae dusky except at base of III. Legs pale, with apical half of mid- and hind femora, apices of tibiae and all tarsi darker. Tibial hairs a little shorter than diameter of tibiae. Antennal hairs acute, about half as long as average diameter of joint on ant. III.

Measurements of specimen : Body 1·63 mm., antenna without joints I and II 0·70 mm., joint ratios 23 : 14 : 16 : 15 + 20, siphunculi 0·03 mm., cauda 0·18 mm., supracaudal process 0·04 mm., apical joint of rostrum 0·05 mm. The apical joint of the rostrum is very blunt, as is typical for monophagous species on Gramineae.

The presence of the well-marked supra-caudal process in *noxius* makes it necessary to retain the species in a different genus from the species of *Brachycolus*, and for this purpose the name *Cavahyalopterus* Mimeur is available.

30. *Galiobium langei* Börner, 1933.

This aphid was described by Börner (1933) from *Galium mollugo*, whose foliage shoots it deforms in a very typical manner. The internodes on the stems become extremely shortened, so that the foliage becomes bunched together in a form suggestive of a " witches' broom." The presence of aphids in these bunches of foliage is indicated by the coming and going of ants which attend the species. As a British species the writer knows of but two records so far, but the distribution is probably very much wider than is known at present. These records are from *Galium mollugo* at Barton, Cambs., 19.ix.44 (*F. H. Jacob*), and Little Chishill, Essex, 5.vii.49 (*H. L. G. Stroyan*). There is also a record of a single alata trapped at Seale Hayne, Devon, by Dr. J. P. Doncaster, and determined by Dr. Hille Ris Lambers.

The following descriptive notes will assist recognition of *G. langei* :

Colour Notes.

The apterous viviparous females are of a uniform dull ochreous greenish colour, with some suffusion of rosy red round the antero-marginal portions of the abdomen (absent in small autumnal apterae), and with the legs, antennae and siphunculi yellowish sclerotic. The alatae have the abdomen dull greenish posteriorly with a dark sclerotic central area, and suffused with rosy red anteriorly. The nymphs are bright rosy red.

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[3] Two further alate females of *C. noxius* were taken in traps at Rothamsted by Dr. C. G. Johnson of the Rothamsted Experimental Station on 13.vii.47 and 30.vii.48 respectively, and the author is indebted to him for particulars of these records and an opportunity to examine the specimens.

MICROSCOPIC MORPHOLOGY.

Apterous viviparous female: Broad oval, rather flattened. Entire insect except for cauda, tibiae and apex of rostrum with cuticle strongly scabrous or papillose, of a yellowish tinge and semi-sclerotic; the papillae are largest and most strongly marked on the siphunculi. Head without antennal tubercles, frons slightly convex owing to a trace of a median prominence. Antennae short, a little less than half body length, processus terminalis hardly longer than basal part of VI; secondary rhinaria absent. Rostrum very short, not reaching second coxae, apical joint normal. Abdominal dorsum without ornamentation of any sort apart from the cuticular papillae; with a blunt median prominence on the 8th tergite, similar to the supracaudal process of *Cavariella* Del Guercio, but less developed. Stigmal pori small, reniform. Siphunculi stout, subcylindrical, slightly incurved for most of their length, markedly constricted to apex, where they are curved outwards; flange rather marked; whole siphunculi covered with large scabrous papillae, which give them an encrusted appearance. Cauda triangular, slightly constricted at base, about two-fifths siphunculi, typically with two pairs of hairs at about half and three-quarters. Rudimentary gonapophyses 3. Legs rather short, femora scabrously imbricate, tibiae with rather few hairs, which are short, spiny, and up to about half the diameter of the tibiae. Chaetotaxy of 1st tarsal joints 2 . 2 . 2. Frontal and antennal hairs very short and inconspicuous, much shorter than diameter of IIIrd antennal joint.

Measurements of one aptera (Little Chishill, 5.vii.49): Body 1·68 mm., antennae without joints I and II 0·58 mm., joint ratios 10 : 7 : 6 : 6 + 7, siphunculi 0·35 mm., cauda 0·14 mm., caudal hairs ? 4, apical joint of rostrum 0·10 mm., 2nd joint of hind tarsi 0·09 mm.

Alate viviparous female: Body normal, not flattened as in aptera, and without the marked cuticular scabrosity of the latter. Head and thorax blackish sclerotic, median ocellus prominently borne on a median frontal convexity. Antennae with joints I and II rather scabrous, remaining joints much more slender than in aptera; whole antenna nearly two-thirds body length. IIIrd joint with 5 to 11 secondary rhinaria scattered along whole length, more or less in a line, IVth joint with 0 to 3; processus terminalis nearly one-and-a-half times as long as basal part of VI. Abdominal ornamentation consisting of indistinct transverse bars on 1 to 3 inclusive; a large sclerotic area occupying the whole width of the dorsum from 4 to 7 inclusive, except for a membranous patch between the siphunculi and small areas round the anterior border of the base of each siphunculus; large marginal sclerites bearing smallish unpigmented tubercles on 2 to 4 inclusive (similar sclerites on 5 and 6 are merged with the main sclerotic area, or nearly so; that on 5 also bears a tubercle); and pleural intersegmental sclerites or "Muskelplatten" on intersegments 1/2 to 3/4 inclusive. A supracaudal process is present as in the aptera. Siphunculi more slender than in aptera, scabrously imbricate but not very strongly so; nearly straight except for a slight outcurving at apex, which is constricted as in the apterae and has a marked flange. Cauda acute triangular, apex much more pointed than in aptera and without basal constriction; typically with two pairs of hairs. Siphunculi, antero-distal part of hind femora and apices of tibiae dark sclerotic. Cephalic and crural hairs as in apterae.

Measurements of one specimen (Little Chishill, 5.vii.49): Body 1·66 mm., antennae without joints I and II 1·02 mm., joint ratios 20 : 13 : 10 : 9 + 13, siphunculi 0·27 mm., cauda 0·13 mm., caudal hairs 4, apical joint of rostrum 0·10 mm., 2nd joint of hind tarsi 0·10 mm., secondary rhinaria on ant. III 7 and 6, on IV 1 and 1.

Hille Ris Lambers (1948) has called attention to the existence of morphological parallels in a number of aphid genera living on Rubiaceae with genera living on Umbelliferae. *Galiobium* is a case in point, showing a number of features (cuticular sculpturing, a supracaudal process and a short processus terminalis) closely similar to those of *Cavariella* Del G. How far such parallels are capable of assisting the elucidation of phylogeny is at present a moot point, but the existence of other examples of a similar nature suggests that this line is worth examination. Apart from the frontal structure, *Galiobium* shows a number of features closely resembling *Myzus cerasi* (F.), and this is perhaps a point of some importance as indicating the possibility of such phenomena being due to convergence.

Material of this species has been deposited in the collections of the British Museum of Natural History and the Department of Zoology, Downing Street, Cambridge; further material remains in the writer's own collection.

31. *Stägeriella necopinata* (Börner, 1939).

Pergandeida galii (Kaltenbach) of Theobald, 1927.

Although this is not strictly a new species to Britain, its position in the list hitherto has rested on a misidentification, and it therefore seems desirable to give the full details of the case in order to clear up any misunderstanding.

Theobald (1927 : 32) described specimens of an aphid from *Galium mollugo* and other bedstraws as *Pergandeida galii* (Kaltenbach), and gave as locality records Sandwich, Hastings, Stowting and near Hythe. Börner (1939) described a species from *Galium verum* as *Hydaphias necopinata* sp. n. Hille Ris Lambers (1947*b*) records Börner's species as found on *Galium purpureum* in Switzerland by Dr. Stäger and on *Galium mollugo* in the Netherlands by himself, and erects the new genus *Stägeriella* for the reception of *necopinata* Börner, which he designates as the genotype.

Among a collection of trapped aphids lent to the writer for examination by Dr. J. P. Doncaster were three slides containing alatae which were provisionally identified as Theobald's *Pergandeida galii* (Kaltenbach). Dr. Hille Ris Lambers, to whom the specimens were shown later, pointed out that the slides contained, not the true *Aphis galii* Kaltenbach, but *Stägeriella necopinata* (Börner). This led the writer to think that an examination of the Theobald material of "*galii* Kalt." was advisable; and in fact when this was done by the courtesy of Mr. F. Laing all this material was found to be identical with the slides determined as *necopinata*.

The position of the Theobald description has caused the writer a certain amount of doubt. Article 31 of the International Rules of Zoological Nomenclature lays down that a specific name based on a misidentification has no standing *even if the species is subsequently placed in a different genus.* This, while clear enough in itself, does nothing to define the position of a species name which is *simultaneously* removed to another genus by the author responsible for the misidentification, as in the present case. There are, in fact, precedents in other groups (e.g. *Oxypoda longiuscula* of Erichson, 1837, but not of Gravenhorst, 1802 (STAPHYLINIDAE)), where a name based on a misidentification has been saved from homonymy by a simultaneous removal to another genus and has enjoyed a long currency among subsequent workers. But in the case quoted recent work has reversed the position, and substituted a later name of unquestioned validity for the name rendered suspect by the manner of its origin.

It is felt on the whole that the best course to follow in this and similar cases is to adopt the name whose use will result in the least possible confusion to subsequent workers; and in the present case this end will be best served by the retention of the more recent name *necopinata* Börner, and the sinking of *galii* Kalt. of Theobald (but not of Kaltenbach) as a synonym under the spirit of Article 31.

The relationship of *Stägeriella* with *Hyadaphis* Kirkaldy has been discussed by Hille Ris Lambers (*loc. cit.*, 657) in connection with the parallelisms displayed by genera from RUBIACEAE and UMBELLIFERAE. Here he draws attention to the fact that the present species can only with difficulty be distinguished from *Hyadaphis obscura* Theobald. There is also a close connection between *Stägeriella* and *Semiaphis* Van der Goot; in fact it is only possible to keep them apart by the absence of a siphuncular flange in *Semiaphis* and the tarsal chaetotaxy (3.3.3 in *Semiaphis* and 2.2.2 or occasionally 3.2.2 in *Stägeriella*). These three genera afford a good example of the incipient divergence of two non-migrating generic groups on related plant families from a common stock migrating from a woody primary host to the secondary hosts colonized by the derived genera. The ancestral stock is at the present time represented by *Hyadaphis* Kirkaldy with migration from Caprifoliaceae to Umbelliferae; the original branch migrating to Rubiaceae cannot be traced among recent forms, but probably *Hydaphias* Börner represents this stock, or at least a side branch of it which has lost the siphuncular flange. The absence of this last feature in both *Hydaphias* and *Semiaphis* is apparently polyphyletic, and this suggests that a character which has been independently lost twice in so small a group of genera is not a safe character on which to base genera, particularly as a vestige of a flange is to be seen in one species of *Semiaphis* (hitherto undescribed) from *Caucalis anthriscus*.

32. *Myzaphis bucktoni* Jacob, 1946.

For a complete description of this species reference may be made to Jacob (1946).

33. *Rhopalosiphum maidis* (Fitch, 1855).

This species, the Corn Leaf Aphis of the United States, and an almost cosmopolitan insect, has only been recorded as a British species since 1945. Dr. L. Broadbent has recorded it among his list of aphid species trapped during the aphid survey carried out by him in North-west Derbyshire in 1945, a total of 30 alatae being taken in traps at Bretton and Oaker. In addition to these examples Mr. A. W. Colling has shown the writer slides of the species taken by Mr. Stapley of the National Agricultural Advisory Service on barley in Cambridgeshire in 1940, which were at the time wrongly identified as *R. padi* (L.); and he also has a few specimens collected from a very heavy infestation of barley which occurred near Peterborough in 1947, and which he believes caused much damage to late-sown barley in that area. Some further alatae trapped by Dr. Broadbent in 1946 and 1947 have also been examined.

In view of the voluminous literature on this aphid in the United States a few comparative notes for distinguishing this from other grass aphids will suffice. If Mordvilko's keys (1922) are used the species can hardly escape detection.

Apterous viviparous female: The body is long and spindle-shaped, the proportion of length to breadth being about 2 : 1. Frons much less sinuate than in *R. padi*. Cuticular reticulation hardly visible; the brown tinge usually present in the cuticle of *padi* is absent in *maidis*. Apical joint of rostrum very short and blunt as in most aphid species holocyclic on GRAMINEAE; this feature is not found to any appreciable extent in *padi*, which migrates from *Prunus*. Abdomen clothed with transverse rows of longish, stiff, black hairs which are much more conspicuous than those of *padi*. Frontal and antennal hairs longer than those of *padi*, those on ant. III being equal to the articular diameter of the joint, and those on V to twice the articular diameter. Head, antennae, legs, cauda and siphunculi blackish, base of femora paler. Abdomen with two pairs of very small marginal tubercles, on 1 and 7 only. Cauda with 4 to 6 hairs.

Measurements of specimens:

Body.	Ant.	Siph.	Cauda.	Caudal hairs.	Antennal joint ratios.
2·32	0·82	0·18	0·13	4	30 : 16 : 16 : 12 + 28
2·24	0·86	0·18	0·11	5	34 : 18 : 17 : 12 + 26
2·89	0·83	0·18	0·13	4	32 : 16 : 16 : 12 + 28
2·40	0·81	0·18	0·14	6	28 : 17 : 16 : 12 + 28
2·30	0·74	0·18	0·11	6	28 : 14 : 14 : 11 + 26
? 2·32	0·81	0·18	0·14	4	30 : 16 : 16 : 12 + 27
? 2·11	0·80	0·18	0·13	4	30 : 17 : 15 : 12 + 26

All length measurements in mm.; antennae measured without joints I and II. All above apterae from Cambridge, 2.vii.40.

Alate viviparous female: The alatae can more easily be confused with *R. padi* than the apterae, but the following differences were detected in the material available: the processus terminalis is shorter, the siphunculi are shorter, more strongly imbricate and less constricted subapically than in *padi*, and the abdominal "Muskelplatten" are much less developed.

Measurements of specimens:

Body.	Ant.	Siph.	Cauda.	Cdl. hrs.	Ant. joint ratios.	Rhin. left antenna.	Rhin. right antenna.
1·92	1·06	0·14	?	5	40 : 25 : 22 : 14 + 32	21/6/1 + 1	23/7/1 + 1
1·76	1·07	0·14	?	?	44 : 23 : 20 : 14 + 32	20/12/4 + 1	20/8/1 + 1
1·97	1·00	0·14	0·11	5	40 : 22 : 19 : 14 + 30	20/6/2 + 1	19/7/2 + 1
2·27	1·13	0·14	0·12	4	46 : 21 : 24 : 15 + 35	19/7/1 + 1	17/5/0 + 1

All length measurements in mm., antennae without joints I and II. The specimens measured were taken respectively at Kennet, Cambs., 5.vii.40; Spalding, Lincs, 21.ix.46; Cardiff, Glam, 7.x.46; and Sutton Bonington, Notts, 12.vi.47.

Das (1918) describes the habits of *maidis* in some detail. The apterae live within the partially curled young leaf bases of various Gramineae, including *Hordeum*, *Avena*, *Cynodon dactylon* and various species of *Panicum*, including the British species *crus-galli*. These latter wild grasses serve as a reservoir of the species from which cereals are invaded in favourable years, causing much damage. Production of alatae is rare except under poor nutritional conditions. Das alludes to the difficulty of distinguishing alatae from those of *padi* in the field, though his *padi*, from what he says of its biology, is presumably *R. insertum* (Walker).

34. *Macrosiphoniella chamomillae* Hille Ris Lambers, 1947.

This species was described by Hille Ris Lambers (1947*a*) from *Matricaria chamomilla* at Bergen-op-Zoom, Netherlands, and subsequently one specimen caught in a trap at Harpenden in 1947 by Dr. C. G. Johnson was identified by Dr. Hille Ris Lambers, who referred to it in a footnote to his description. The writer has been enabled to see this latter specimen through the courtesy of Dr. Johnson. The specific characters which distinguish the present aphid are the very long slender siphunculi having a much narrower reticulated area at the apex than the other species of *Macrosiphoniella* with long siphunculi (*tapuskae*, *sejuncta*, *persequens*) ; the alatae have also occasionally a few rhinaria on the IVth antennal segment, according to Hille Ris Lambers, a character not found in other species of the genus except *sanborni*, which has short siphunculi.

The measurements of the British specimen are as follows : Body 3·36 mm., antennae without joints I and II 3·31 mm., joint ratios 54 : 45 : 39 : 13 + 56, siphunculi 0·72 mm., cauda 0·42 mm., caudal hairs 12, apical joint of rostrum 0·14 mm., 2nd joint of hind tarsus 0·14 mm., secondary rhinaria on ant. III 60 and 55.

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SUMMARY.

The most recent available list of British APHIDIDAE, that of Kloet and Hincks (1945), has been rendered out of date by numerous additions to systematic knowledge due to the researches of various European workers.

The aim of the present paper is to bring together all species either recorded for the first time in Britain since 1945, or first described from British material between 1945 and the present time. A list of these species up to the end of *Rhopalosiphum* Koch is given in the introduction.

These species, numbering 34, are then discussed separately, and morphological and biological notes given to assist diagnosis in cases where such diagnosis is not possible from previous literature. Synonymy is not discussed, except in so far as it is essential to the discussion of the species treated.

The second part of this publication will complete the list of new British species from *Rhopalomyzus* Mordvilko onwards, and will contain an appendix referring to certain old descriptions recently recognized satisfactorily for the first time.

Phylogenetic relationships have not been discussed in the present paper ; but certain amendments have been made in the order of genera as given by Kloet and Hincks, in order to represent more accurately the natural relationships of certain genera.

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CORRIGENDUM.

Page 116. The species listed as *Cavahyalopterus noxius* (Mordvilko) is not that species, but *C. mühlei* (Börner, 1950), living on *Phleum pratense* and causing a typical streaky discoloration. The supracaudal process in this species is shorter than in *noxius*, being only about ¼ as long as the cauda or less (about ½ in *noxius*).

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THE SEASONAL DISTRIBUTION OF *CULICOIDES IMPUNCTATUS* GOETGHEBUER (DIPTERA: HELEIDAE (CERATOPOGONIDAE)) WITH A DISCUSSION ON THE POSSIBILITY THAT IT MAY BE COMPOSED OF TWO OR MORE BIOLOGICAL RACES.

By D. S. Kettle, M.Sc.(Lond.), F.R.E.S.

Manuscript received 10th February, 1950.

(Read 3rd May, 1950.)

R b.

With 4 Tables and 8 Text-Figures.

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1. Introduction.

In an earlier paper (Kettle, 1949) a description was given of an attempt in 1948 to control *Culicoides impunctatus* Goetghebuer by means of the application of D.D.T. residual sprays to vegetation. It was shown that the treatment had no discernible effect upon the midge population, so that it was valid to regard all the observations as having been made on an untreated population and to make direct comparisons between weekly catches irrespective of their relation to the application of D.D.T.

In 1948 observations were made at two sites, Bannachra and Wester Bannachra, which were three-quarters of a mile apart and 300 ft. above sea level, on the north side of Ben Bowie, Loch Lomond. At each site equal numbers of observations were made, under both woodland and moorland conditions, so that reference will be made during the course of this paper to four areas :

(i) Bannachra Woodland,

(ii) Bannachra Moorland,

(iii) Wester Bannachra Woodland and

(iv) Wester Bannachra Moorland.

Observations on the *C. impunctatus* population were made at 44 catching stations, of which 11 were in each area. Each station consisted of three metal cylinders (12 in. high × 5 in. diameter), placed vertically above each other on a wooden post so that their centres were 2 ft., 6 ft. and 10 ft. above the ground. To trap the midges each cylinder was covered with a sheet of celluloid (18 in. × 12 in.) treated with "Stopmoth," a proprietary tree-banding grease. The celluloid sheets were changed weekly, and the ensnared *Culicoides* removed, rendered grease-free and preserved in 70 per cent. alcohol for later identification. This is practically the same technique as that described by Broadbent *et al.* (1948), with the exception that in these experiments the cylinders were painted black instead of white, since Hill (1947) had found female *Culicoides* to be attracted to dark colours.

Observations were begun in 1948, in the second week of May, and continued at Wester Bannachra until the end of the second week of September (a total of 18 weeks), but on account of the illness of my assistant the observations at Bannachra were discontinued after the end of the first week in August (a total of 12 weeks). This did not cause much loss of information as the catches during the first two and the last four weeks were insignificant. In 1949 observations were made only in Bannachra Woodland, and were carried out from the start of May until the end of August, a total of 17 weeks. On account of the small number (10 per cent.) caught in 1948 on the 2ft. traps in this area, only the 6 ft. and 10 ft. traps were used in 1949.

The arrangement of the traps and an account of the topography of the two sites is given by Kettle (1949).

The seasonal abundance of *C. impunctatus* was investigated by Hill (1947) at Knowsley Park, Liverpool, in 1945, and by Parker (1949) in 1947 at Rossdhu Park, Loch Lomond. Both workers obtained a unimodal distribution curve (figs. 4 and 5). At Liverpool the first adults appeared at the beginning of May and built up to a maximum in the middle of June, after which the number decreased until the first week in August, when the last adults of the season were caught. Parker's figures were about a month later than those of Hill.

Thus at Rossdhu the first adults appeared at the start of June, the maximum was obtained at the beginning of July, and the last adults were caught at the end of August. Both of these sets of observations were made only on female *C. impunctatus*, since Hill obtained no males, and Parker too few for analysis. This unimodal distribution curve was interpreted as indicating that *C. impunctatus* has only one generation a year, and Hill obtained adequate corroboration of this by following the changes in the larval population. Quite a different seasonal distribution was obtained at Bannachra, and it is proposed to present these results and then to discuss their significance.

Owing to the pressure of other work it was not found possible in 1948 to remove the catches from all the traps during the fourth and fifth weeks. However, at least 6 out of the 11 catching stations in each area were examined. Thus, at both Wester Bannachra Woods and Bannachra Moorland, 6/11 and 7/11 of the catching stations were examined during the fourth and fifth weeks respectively, whilst at Wester Bannachra Moorland and Bannachra Woods all stations were examined in the fourth week and 6/11 in the fifth week. In order to compare these catches with those of other weeks the following correction was introduced :

$$a = \frac{bd}{c}$$

where a = estimated total catch of male or female *C. impunctatus* in weeks 4 or 5.

b = number of male or female *C. impunctatus* removed from x stations in weeks 4 or 5.

c = number of male or female *C. impunctatus* removed from x stations in all weeks except 4 and/or 5.

and d = number of male or female *C. impunctatus* removed from all stations in all weeks except 4 and/or 5.

This correction was applied because it was found that there were large consistent differences between the catches at the different stations.

Also, in the fifth week at Wester Bannachra and the seventh week at Bannachra the traps were exposed for 9 days instead of 7, and the total was adjusted as follows :

$$a = b - \tfrac{1}{8}(b + c)$$

where a = estimated number of male or female *C. impunctatus* caught in week 5 or 7.

b = number of male or female *C. impunctatus* caught in week 5 or 7.

and c = number of male or female *C. impunctatus* caught in week $b + 1$ = 6th or 8th week.

It was thought that this was a more accurate adjustment than merely taking seven-ninths of the catch in the fifth or seventh week, because it makes allowance for changes in the size of the population during the week. It will be seen from figs. 1–3 that these changes are considerable.

2. Seasonal Abundance of *C. impunctatus*.

(*a*) 1948.—The weekly catches of male and female *C. impunctatus* in the four areas are shown in figs. 1 and 2. It will be noticed that the seasonal distribution is markedly bimodal with peaks in the first week of June and the middle of July and, moreover, that this distribution is the same for both sexes and in all areas. It might be wondered how far the corrections applied above have influenced this result. In all areas there is a complete seasonal record

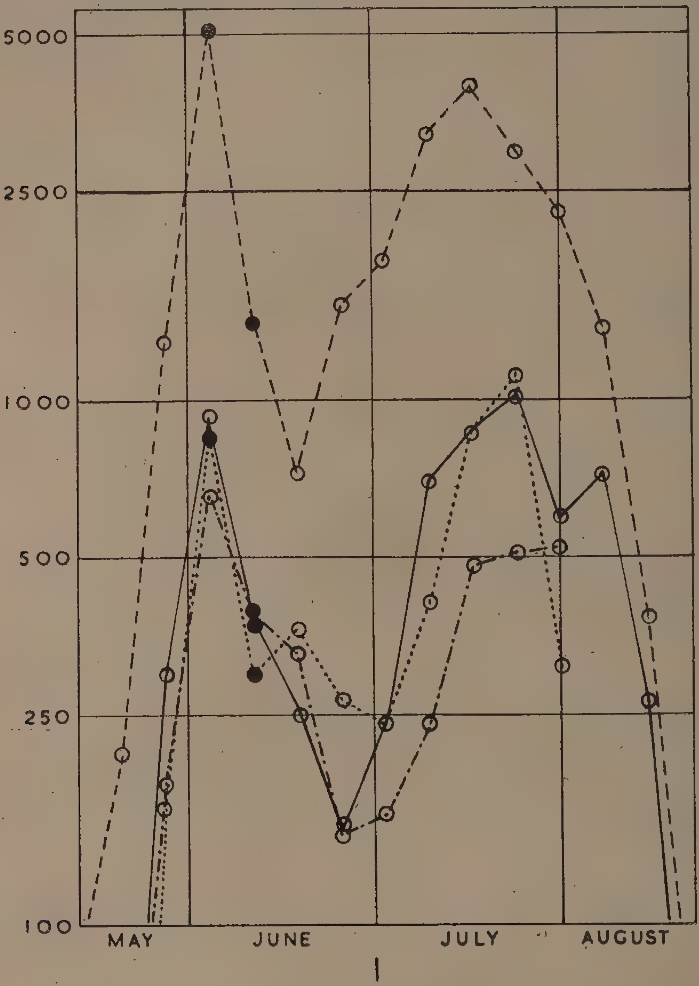

Fig. 1.—The seasonal distribution of male *C. impunctatus* in 1948. Continuous line represents Wester Bannachra Moorland, the broken line Wester Bannachra Woodland, the dotted line Bannachra Moorland, and the dash-dot line Bannachra Woodland. Closed circles indicate the calculated catch when all the stations were not sampled. (For details of the calculation see text).

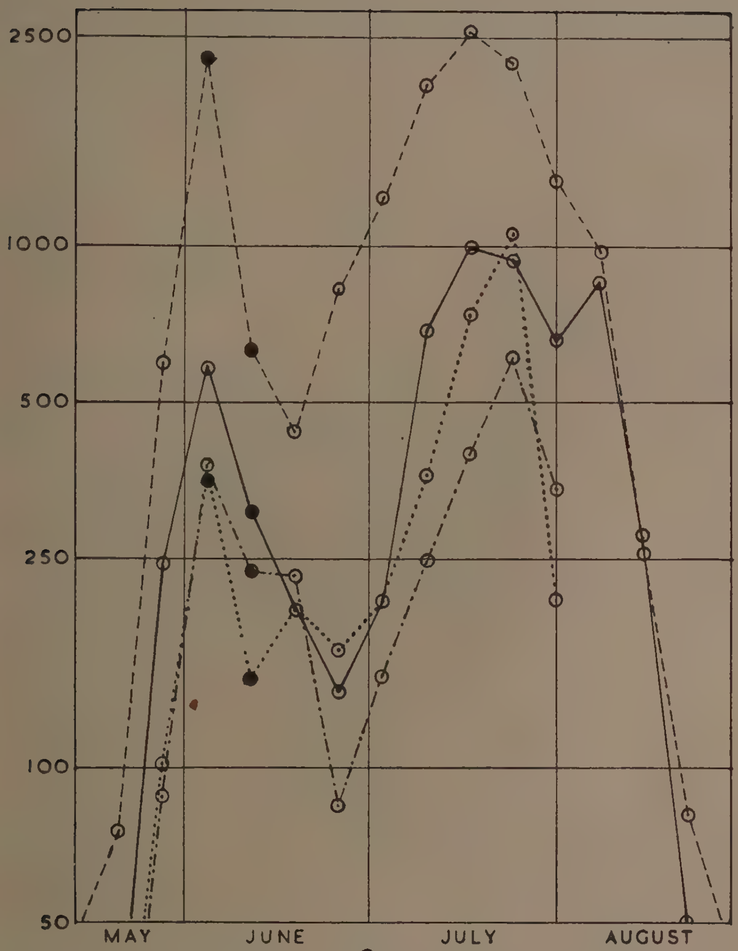

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FIG. 2.—Seasonal distribution of female *C. impunctatus* in 1948. (For details see fig. 1).

for some stations. For Bannachra Woods and Wester Bannachra Moorland there were six complete station records in each area, and for Bannachra Moorland and Wester Bannachra Woods there were two. These records for male *C. impunctatus* are shown in fig. 3, after the correction for 9 days' exposure in the fifth week (Wester Bannachra) and seventh week (Bannachra) has been made. The seasonal distribution of the females is very similar to fig. 3, and has therefore been omitted. It is clear that the bimodal nature of the distribution is independent of the correction for incomplete station records.

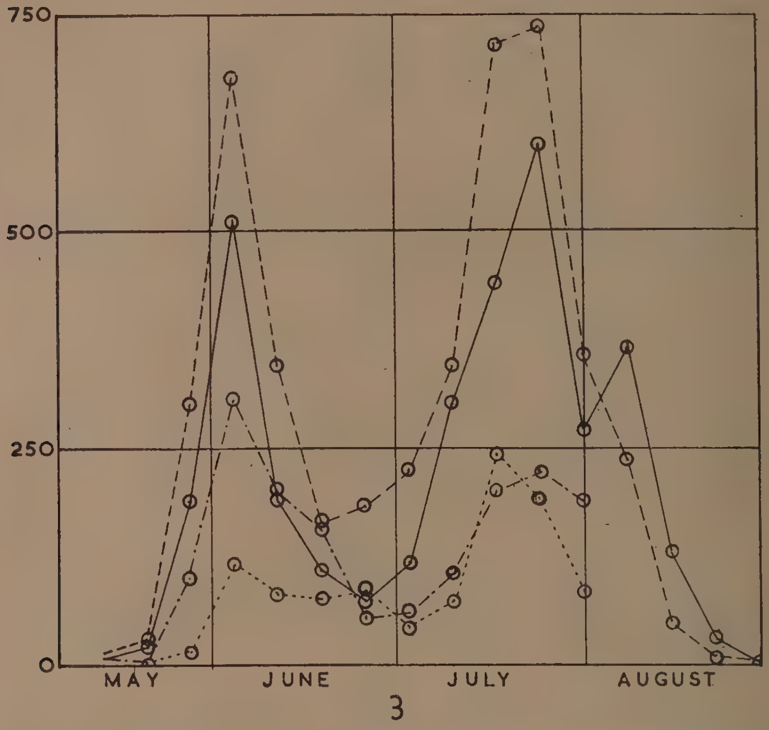

FIG. 3.—1948 seasonal distribution of male *C. impunctatus* for catching stations with complete seasonal records. (For details see fig. 1 and text.)

(*b*) 1949.—In 1949 adult *C. impunctatus* appeared early in May and the population rapidly built up to a maximum at the end of May (males) and the first week in June (females) (fig. 4), after which the numbers sharply declined and remained very low throughout July. This was followed by a partial recovery in August when there was a small but definite increase in numbers in the middle of the month, but this was only temporary and by the end of August very few *C. impunctatus* were to be found (fig. 4). Therefore, in 1949 as in 1948, the seasonal distribution was bimodal, but whereas in 1948 the two peaks were subequal, in 1949 the first peak was very large and the second insignificant. It is also of interest that the first maximum of female *C. impunctatus* occurred in the same week in both years, whilst it was a week

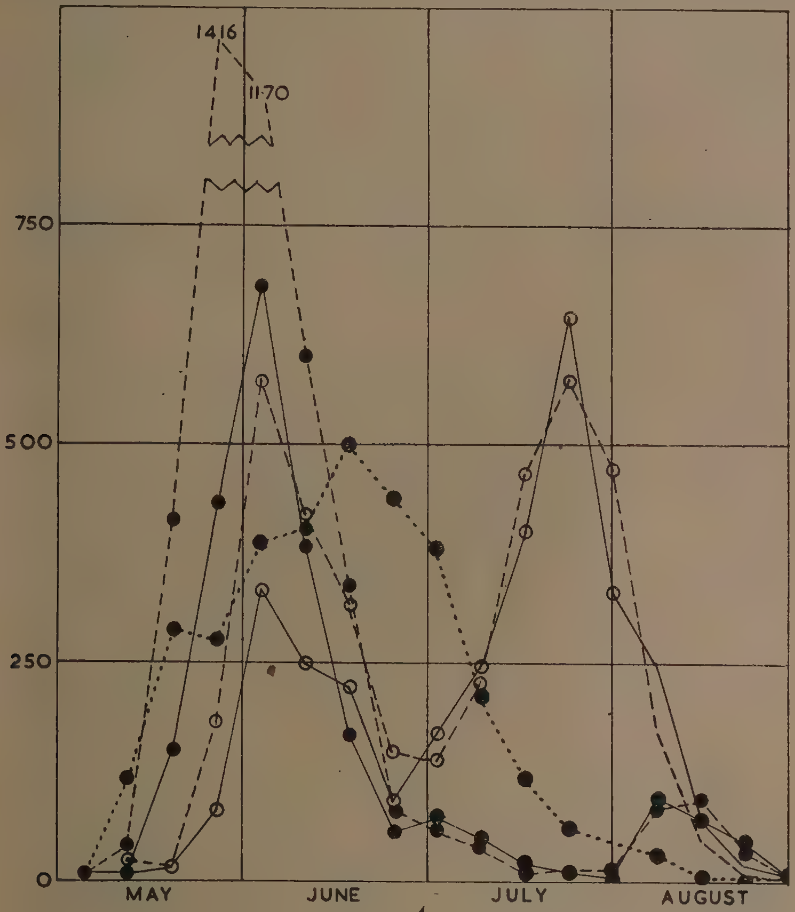

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Fig. 4.—Seasonal distribution of male and female *C. impunctatus* at Bannachra woods in 1948 and 1949, and the distribution of female *C. impunctatus* at Liverpool in 1945 (Hill, 1947). Open and closed circles represent 1948 and 1949 respectively. Broken and continuous lines indicate male and female *C. impunctatus* respectively. The closed circles joined by a dotted line indicate Hill's data. The end of the 1948 distribution curve has been added by analogy with the observations at Wester Bannachra.

earlier for male *C. impunctatus* in 1949. On the other hand, the second maximum of both sexes was 2–3 weeks later in 1949. Although no exact data are available it is common experience that normally *C. impunctatus* is abundant during June, July and August (Cameron *et al.*, 1946) (Cameron, 1947), so that the 1949 distribution, with hardly any *C. impunctatus* after the end of June, is abnormal.

(*c*) 1947.—In 1947 two workers (Parker and Currie) were estimating the *Culicoides* population at Rossdhu, 3 miles from Bannachra, by means of sweeping with fine-meshed nets. Parker was concerned with seasonal changes in the population, and, as a result, he collected on days when the environmental conditions were more or less ideal for *Culicoides* activity (Parker, 1949), whereas Currie (private communication) was concerned with the effect of different meteorological conditions on the activity of *Culicoides*. Consequently, Currie made regular daily collections and recorded the meteorological conditions existing at the time. His data show quite clearly that when the air movement was stronger than " light breeze " no midges were captured. (Currie recognized five wind speeds : calm, light breeze, strong breeze, light wind, and strong wind, but these definitions are not the same as those on the Beaufort scale). In fig. 5, therefore, I have selected those readings when the air movement was recorded as " calm " or " light breeze."

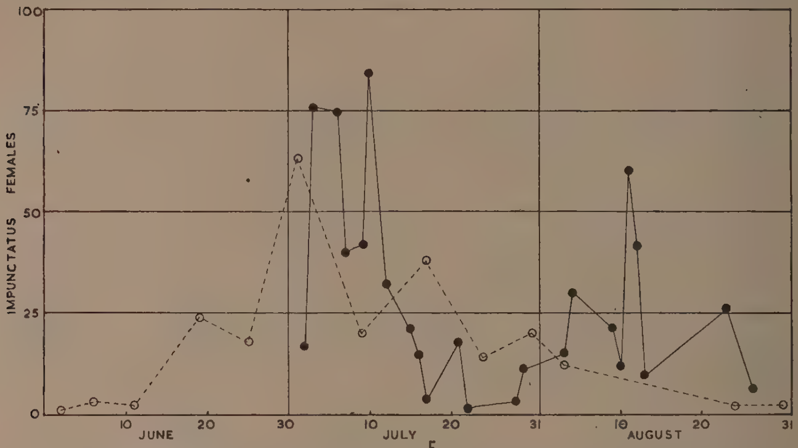

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FIG. 5.—Seasonal distribution of *C. impunctatus* females in 1947 at Rossdhu Park, Loch Lomond. Open circles and broken line indicate Parker's data (1949), closed circles and continuous line represent Currie's data (private communication).

Hill (1947) had shown that the activity of *C. impunctatus* was closely related to sunset and sunrise. In accordance with this, Currie made two daily observations, at 3 hours before sunset and at sunset, but as he caught so few *C. impunctatus* during the earlier observations, only his sunset results have been illustrated in fig. 5. Parker, on the other hand, swept at regular times in relation to sunset, and recorded the maximum number of *C. impunctatus* captured during any one of the evening's observations. This difference in technique may account for the discrepancies between their results on the same day, as, for example, when on 9th July Currie recorded more *C. impunctatus* females than Parker, whilst on 17th July the positions were reversed.

Both workers obtained large numbers of *C. impunctatus* during the first half of July and then, according to Parker, the numbers decreased until the end of August, but Currie recorded a second smaller but definite increase in numbers in the middle of August. This contradiction is readily resolved because Parker, being on holiday at the time, made no observations between the 3rd and 24th of August, and consequently completely missed the second maximum. Therefore Currie's observations give a better indication of the seasonal abundance of *C. impunctatus* and show that in 1947 it had a bimodal seasonal distribution at Rossdhu.

It is of interest, when comparing results obtained at Rossdhu with those at Bannachra, to note that in 1949, although no exact observations were made, the *Culicoides* density at Rossdhu, as determined by the amount of annoyance caused to the resident fresh-water biologist, paralleled the quantitative results obtained at Bannachra. The amount of annoyance was estimated as greater or less than that of the previous week.

3. Discussion on the Interpretation of the Bimodal Seasonal Distribution of *C. impunctatus.*

It seems that *C. impunctatus* had a bimodal seasonal distribution at Loch Lomond in 1947, 1948 and 1949, although between these years there are a number of differences which need to be explained. Firstly, why was the *C. impunctatus* season about one month later in 1947 than in 1948, and, secondly, why was the second maximum in 1949 both delayed and reduced ?

The bimodal distribution could be due to :

(*a*) The effect of environmental conditions upon a fundamentally unimodal distribution.

(*b*) *C. impunctatus* having two generations a year instead of only one as is usually supposed.

(*c*) *C. impunctatus* being composed of two separate entities whether species, varieties or races.

(a) *Climate and the Seasonal Distribution of* C. impunctatus.

(i) *Could climatic factors have produced a bimodal from a unimodal seasonal distribution ?*

The "sticky trap" method of estimating the size of an insect population is influenced by any factor which affects the activity of the insect. Thus, if the population remains numerically unaltered whilst the activity of the insect is doubled, the traps will catch twice as many insects. Such activity factors are likely to operate for only short periods of time, and it is thought that these have been more or less smoothed out by exposing the traps for a week. Compare the regularity of the changes shown in figs. 1–4 with those in fig. 5, when observations were of short duration. An effect probably due to activity, can be seen in the low catch of the first week in August on Wester Bannachra Moorland.

In 1948 the bimodal curve was obtained at two sites three-quarters of a mile apart, and in both woodland and moorland, so that it cannot be related to changes in the micro-climate. If it is due to climatic factors it must be related to more widespread changes. Although no meteorological records were made in the sites, it has been possible, through the courtesy of the Burgh Surveyor, Helensburgh, to consult the meteorological records for Valvehouse meteorological station, which is at the same altitude as the sites (293 ft. above sea level) and only 1¾ miles from Wester Bannachra and 2½ miles from Bannachra.

These records have been examined to find out whether the periods of midge abundance or scarcity coincided with any particular climatic conditions. The factors most likely to affect the activity of *Culicoides* are temperature, humidity, rainfall and wind. Wind is likely to be of great importance on exposed moorland sites, but insignificant in dense woodland. Since the bimodal effect is equally well marked in both the woodland and moorland areas, wind can be disregarded as the causative agent. As the estimates of the adult population are the result of a week's continuous trapping, they should be compared with similar estimates of climatic factors. The mean daily maximum and minimum temperatures and the total rainfall for each week are graphically represented in figs. 6 and 7. The only humidity records were single daily readings taken at 09.00 hours G.M.T., and since *C. impunctatus* is inactive at this time of the day, these observations have not been analysed. For the present purpose the humidity can be regarded as a combination of temperature and rainfall.

In 1947 the first peak occurred at the start of July, when both the rainfall and the mean daily temperature were below average. During the period between the peaks the rainfall was about normal, and the temperature above average (Table I, figs. 6 and 7), whilst the second peak coincided with a hot, dry spell which continued throughout August. The summer of 1948 was wet and cold with only two periods of warm, dry weather. The first of these occurred in the middle of May, before *C. impunctatus* was present in any number, and the second, in the latter half of July, coincided with the second maximum of *C. impunctatus*. In 1949 the weather during the first peak of *C. impunctatus* was average in rainfall, whilst the temperature was below average. This was followed, during the second half of June and the first half of July, by a hot, dry spell which in turn was succeeded by a wet, cool period lasting throughout the rest of July and the first half of August.

The second peak of *C. impunctatus* abundance in 1949 occurred under these wet, cool conditions, so that of the six periods of *C. impunctatus* abundance, two each in 1947, 1948 and 1949, two occurred during periods of warm, dry weather, two during spells of cool, wet weather, one during dry days of average temperature, and the other during cold days of average rainfall.

The meteorological conditions during the periods between the two maxima are equally varied. Thus, one occurred during a warm period of normal rainfall, a second during cool, wet weather, and the third under hot, dry conditions.

It can be concluded that it is most improbable that the bimodal seasonal distribution of *C. impunctatus* could be due to the effect of temperature or rainfall on a fundamentally unimodal distribution.

(ii) *The effect of climatic factors on the seasonal distribution of* C. impunctatus.

Although climatic factors did not produce the bimodal seasonal distribution, they were able to modify it considerably. Thus, in 1947, the *C. impunctatus* season was a month late compared with 1948 and 1949, and this was almost

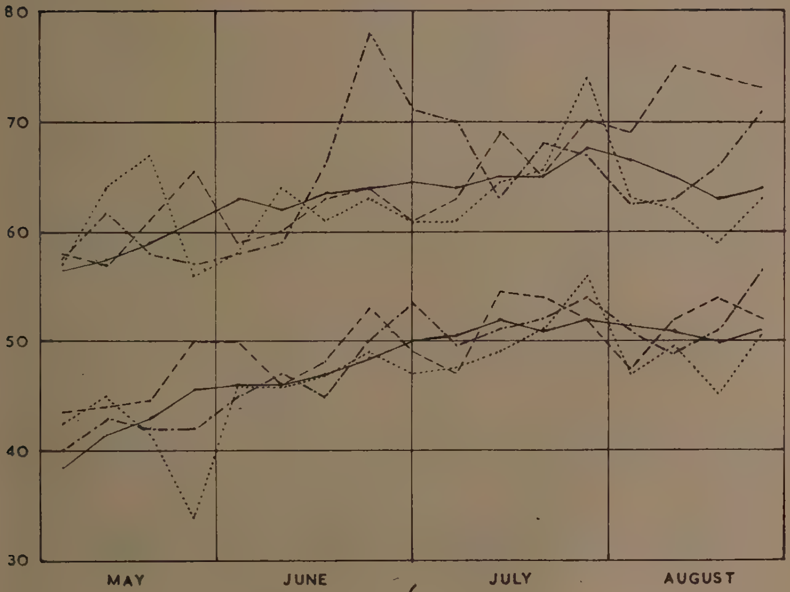

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FIG. 6.—Mean daily maximum and minimum temperature ° F. in each week of the period May–August. Continuous line indicates the 1937–46 mean, the broken, the dotted, and the dash-dot lines represent 1947, 1948, and 1949 respectively.

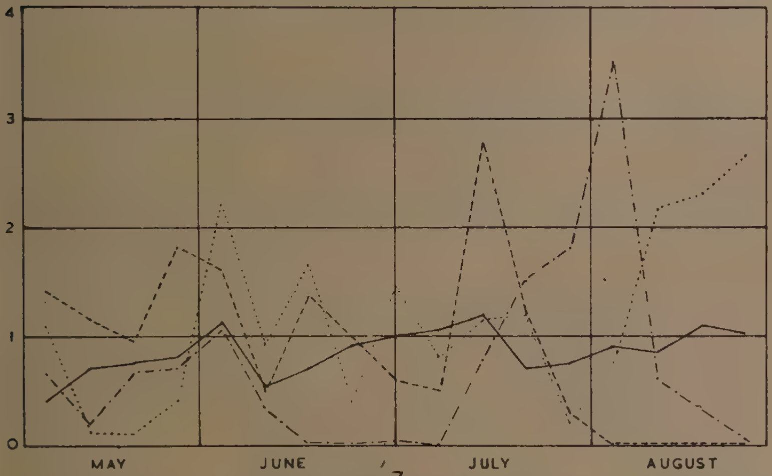

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FIG. 7.—Weekly total rainfall in inches for the period May–August. (For other details see fig. 6).

TABLE I.—*Mean Daily Maximum and Minimum Temperatures ° F., and Total Rainfall in inches for each Month.*

The figures for 1947, 1948, and 1949 are given as differences from the standard (i.e. mean 1937–46).

	Rainfall in inches.				Mean daily maximum Temp. ° F.				Mean daily minimum Temp. ° F.			
Month.	Mean 1937–46.	1947.	1948.	1949.	Mean 1937–46.	1947.	1948.	1949.	Mean 1937–46.	1947.	1948.	1949.
January	5·98	+0·12	+2·86	+0·65	40·6	− 0·9	0·0	+4·8	31·2	+1·2	+1·8	+3·6
February	4·86	−4·25	+0·95	+0·59	43·9	−10·7	−0·2	+2·3	33·7	−9·3	+0·6	+2·6
March	3·88	+0·83	+1·09	−0·94	47·1	− 8·0	+2·6	+0·5	35·3	−5·4	+2·3	−1·2
April	2·75	+4·06	+0·50	+3·59	52·5	− 2·6	−0·2	−0·1	38·5	−0·1	+0·9	+2·0
May	3·17	+2·38	−1·15	−0·62	58·6	+ 0·2	+1·6	−0·3	41·7	+2·3	−1·5	+0·2
June	3·49	+0·96	+1·35	−2·43	63·1	− 1·3	−1·4	+3·6	47·2	+2·2	−0·3	+1·0
July	4·22	+1·03	+0·56	−0·19	65·0	+ 0·1	+0·1	+2·2	50·7	+0·7	−0·5	+0·6
August	4·28	−4·24	+3·56	+0·53	64·7	+ 7·7	−2·6	+0·8	50·7	+0·9	+2·1	+1·3
September	4·66	+0·86	+2·88	.	60·5	− 0·2	−1·5	.	47·5	−0·1	−0·3	.
October	6·01	−3·12	+5·16	.	54·0	+ 1·0	−1·0	.	42·7	+1·7	−0·1	.
November	5·32	+3·63	−0·72	.	48·0	− 0·3	+1·4	.	38·1	−2·2	+1·2	.
December	5·19	−1·99	+2·10	.	44·0	0·0	+1·4	.	34·9	+0·6	+2·2	.

TABLE II.—*Percentage Distribution of* C. impunctatus *Larvae in Depth at Luss and Bannachra.*

As a result of the Luss observations in 1947 only the top two inches of soil were sampled in 1949. This modification was justified later by the close agreement between the two distributions.

	Luss, Autumn, 1947.			Bannachra, Spring, 1949.	
Depth in inches.	2nd stage.	3rd stage.	4th stage.	3rd stage.	4th stage.
0–1	91·4	85·2	74·4	78·7	76·9
1–2	8·6	12·4	22·4	21·3	23·1
2–3	0·0	2·4	2·4	No observations.	
3–4	0·0	0·0	0·8		
No. of larvae	58	210	125	61	606

certainly brought about by the unusually long, cold spell in the early part of the year (Table I). Indeed, it was so cold that Loch Lomond froze over for the first time since 1895. It will be suggested later that the long, hot, dry spell in 1949 caused considerable mortality among the *C. impunctatus* population. There was also a long, hot, dry spell in August, 1947, and yet a large number of *C. impunctatus* survived to emerge in 1948. The difference between the effect of these two dry spells is to be found in the rainfall of the previous months. In 1947 the rainfall was above average in May, June and July (15·25 in., Cf. 10·88 in.), so that although only 0·04 in. of rain fell in August the total rainfall in May–August was average (15·29 in., Cf. 15·14 in.), whereas in 1949 the rainfall was 3·24 in. below average in May, June and July (7·64 in., Cf. 10·88 in.), and only 0·34 in. of rain fell between 6th June and 12th July (Table I, fig. 7). Therefore it is likely that the water content of the soil was reduced less by the 1947 dry spell than by the one in 1949.

As a result of this prolonged drought in 1949 the breeding place of Bannachra Woods dried out so that the *Sphagnum* turned white. At both Bannachra and Wester Bannachra it was possible to walk dry shod over the whole site, even through places which had to be circumvented in 1948 because they were so marshy. It was this drought which delayed the appearance of the second peak and caused the reduction in numbers. It is known that most *C. impunctatus* larvae occur in the top inch of soil, and nearly all in the top two inches (Table II) and they must have been very much affected by the drying out of the soil, which must also have caused an equal or higher mortality among the eggs deposited by the adults of the first peak. This is borne out by the fact that, notwithstanding the larger number of adults in the first peak, no young larvae were found until the middle of August (Table III) and yet the larval sampling technique is known to detect first instar larvae. It is significant that following the break in the weather in the latter part of July and early August adults begin to appear (fig. 4). It seems that the rain enabled the surviving larvae to pupate and emerge.

Some support is to be found for this view in the many reports of an absence of midges during July, and an unusual number during August and September. None of these reports were quantitative, but investigation of some has shown that *C. impunctatus* adults were present in considerable numbers during the period. This may be due to variations in the extent of drying out which the soil experienced, so that in some areas the drought may have delayed the appearance of the second peak, perhaps by restricting the movement and feeding of the larvae in the soil, without causing any appreciable mortality. As a result, the time interval between the two maxima was greater than in 1947 and 1948.

It is concluded that although climatic factors may considerably modify the bimodal seasonal distribution they cannot, in themselves, account for it.

(b) *Is* C. impunctatus *bivoltine?*

The obvious method of answering this question is to make regular observations on the larval population in the soil during the summer and to see whether there is a generation of rapidly developing larvae. With this in mind, an attempt was made in the spring of 1949 to locate the breeding place in Bannachra Woods by dividing the area suspected into squares 6 yards ×

6 yards and taking three samples from each square. The samples were taken with a 3-in. diameter soil borer, and the top two inches of each sample were examined separately in the laboratory for larvae of *C. impunctatus*. It had previously been found that the larvae of *C. impunctatus* were almost entirely confined to the top two inches (Table II). The consistency of the results (fig. 8) suggests that three samples gave a reasonable estimation of the larval density in a square. The area of three samples was approximately 1/2000th of the total area of a square, so that an estimate of the actual larval population in a square can be obtained by multiplying the numbers in fig. 8 by 2000.

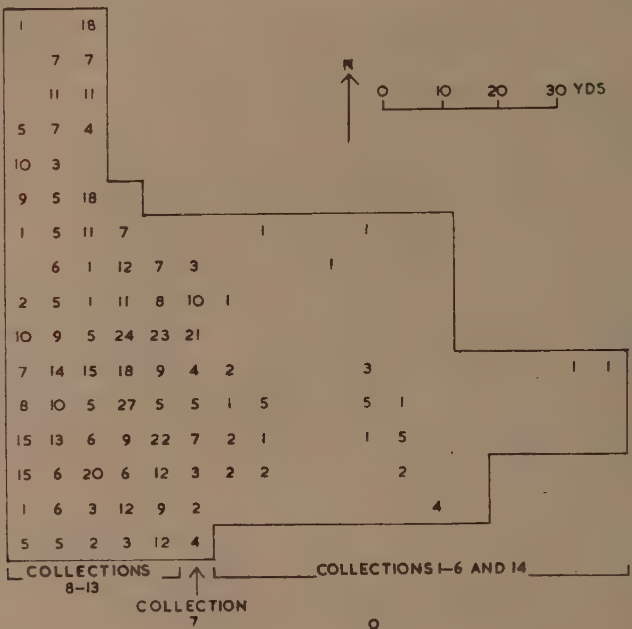

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FIG. 8.—Distribution of *C. impunctatus* larvae at Bannachra Woods, 1949. The figures represent the number of larvae, except zero, found in three samples from each square (6 yds. × 6 yds.).

(i) *Field observations on* C. impunctatus *larvae.*

When the results of the larval survey were plotted it was found that the larvae were concentrated along the western side of the sampled area and were very sparse in the central and eastern sections (fig. 8). Therefore, comparisons of larval density can only be made between collections taken from the same section of the breeding area. Thus, collections 1–6 and 14 were made in the eastern section, collections 8–13 in the western section, and collection 7 made at the junction of the two. Obviously, the more informative comparisons will be made in the western section where the larvae were more numerous.

If *C. impunctatus* were bivoltine the second maximum would represent the progeny of the adults of the first peak, and it would be anticipated that the following sequence of events would occur. Firstly, the larval density would rapidly decrease to zero as the larvae pupate. This would be followed by a rapid increase in the adult population. Then, after an interval during which the eggs were being matured and the embryonic development completed, large numbers of small larvae would appear. These would grow rapidly to complete their development and to emerge as the adults of the second generation. If, on the other hand, *C. impunctatus* were not bivoltine this sequence of events would be considerably modified. The larval density would fall more slowly to reach about half of its initial value at the end of the pupation of the adults of the first peak. Between the peaks the larval population would consist of very large and very small larvae, with hardly any larvae of intermediate size.

Table III.—*Result of Larvae Sampling at Bannachra Wood in* 1949.

Collections 1–14 were made during the mapping of the breeding place, whilst collections 15–21 were taken from squares sampled earlier.

The number of larvae previously found in an equal number of samples from the same squares is given in brackets.

			No. of larvae.			Larval density per sq. yd.	
Collection No.	Date of collection.	No. of samples.	2nd.	3rd.	4th.	Eastern part.	Western part.
1	Feb. 25	42	0	1	4	22	.
2	March 7	42	0	2	7	39	.
3	,, 16	18	0	6	6	121	.
4	,, 18	45	0	1	3	16	.
5	,, 23	21	0	2	4	52	.
6	April 8	21	0	1	3	35	.
7	,, 14	36	0	10	47	290	
8	,, 21	33	0	7	92	.	550
9	,, 27	36	0	20	125	.	738
10	May 4	36	2	4	81	.	443
11	,, 11	36	0	3	84	.	443
12	,, 19	36	0	3	80	.	423
13	,, 31	36	0	1	70	.	362
14	June 9	36	0	0	2	10	.
15	,, 30	12	0(0)	0(3)	4(15)	0	122
16	July 11	12	0(0)	0(3)	4(16)	0	122
17	,, 14	12	0(1)	2(3)	0(9)	0	61
18	,, 21	12	0(0)	3(6)	0(24)	0	92
19	August 5	12	0(0)	3(5)	*2(21)	31	122
20	,, 12	12	0(1)	8(1)	0(26)	.	122
21	,, 19	12	6(1)	1(3)	1(26)	.	122

* One of these two larvae pupated and emerged as a female *C. impunctatus* on 23.viii.49.

The pupal stage of *C. impunctatus* lasts 1–2 weeks, and the adults first became numerous in the third week of May (fig. 4), so that very few larvae had pupated by the end of April, when the larval density in the western section was about 650 per square yard (Table III). The adult population reached its peak at the end of May so that any individuals which were then in the larval stage were unlikely to emerge in time to contribute to the first peak. Therefore, if *C. impunctatus* were bivoltine, the larval density should be low at the end of

May, but in fact it was 362 per square yard, which is more than half the prepupational larval density at the end of April. This is a very strong argument against the hypothesis that the bimodal seasonal distribution is due to *C. impunctatus* having two generations a year.

It has already been suggested in the previous section that the small number of *C. impunctatus* in the second maximum was due to the unusually hot, dry summer, which dried up the breeding place and destroyed the larvae. At the same time, on account of the pressure of other work, the number of larval samples had to be reduced to 12, each being taken from a different square, and for other reasons half of these were taken from the barren eastern section, except in collections 20–21 when all 12 samples were taken from the western section.

In view of the low larval density it is very doubtful whether this small number of samples is sufficient to provide a valid estimate of the composition of the larval population, and the following comments on the later collections (15–21) are subject to this criticism.

The most puzzling feature of these collections is the origin and fate of the 3rd-stage larvae which occur from 14th July–19th August. If they are the progeny of the first peak, why were no 1st or 2nd-stage larvae found until 19th August, especially since the examination technique is known to recover 1st-stage larvae? On the other hand, if the 3rd-stage larvae have overwintered, and support for this is found in the fact that the number of 3rd-stage larvae is less than that found previously, except on 12th August (Table III), when are they going to emerge as adults? It is certain that those found on 12th August would not emerge during the small second adult peak in August.

Also, if the small larval numbers are due to the drought, why should it apparently have a selective effect on the 4th stage and produce a larval population with a higher proportion of 3rd instars? This is rendered particularly inexplicable since the 4th-stage larvae are found slightly deeper in the soil than the 3rd stage (see Table II), and should therefore be more resistant to drying up. It will be realized that the evidence provided by collections 15–21 throws no light on the nature of the second maximum.

(ii) *Laboratory observations on* C. impunctatus *larvae.*

In order to ensure that the larvae identified as *C. impunctatus* did belong to this species, 246 4th-stage larvae from the March–May collections were kept in the laboratory in order to obtain the adult insects. Fifty-one adults (27 males and 24 females) emerged during the period 14th April to 8th June, with a maximum in the middle of May. This unimodal emergence curve does not necessarily indicate that all the larvae collected belonged to the first maximum because nearly four-fifths of the larvae failed to emerge. It has been found repeatedly with various species of *Culicoides*, including *C. impunctatus*, that adult emergences are only obtained very shortly after the larvae have been brought into the laboratory. This appears to be due to inadequate feeding, since the fat body, which in wild larvae fills the abdomen, is very poorly developed in larvae which have been kept in the laboratory for one to two months. Therefore the laboratory rearing of wild-caught *C. impunctatus* larvae provides no answer to this problem.

(iii) *Observations of other workers on the duration of the life cycle in* Culicoides.

If there were two generations of *C. impunctatus* in 1947–49 the short summer life cycle must have been completed in about 7 weeks, that is, in the interval between the two peaks. This possibility can be examined in conjunction with the data provided by Hill (1947). She found that two weeks were required for the maturation of the eggs within the body of the female after the first blood meal, then a further two weeks were required after oviposition to complete the development of the larva within the egg, and leaving aside the duration of the larval life, the pupal stage lasted another week. There are, therefore, only two weeks left for the larval life if the whole cycle is to be completed in seven weeks. Observing the larval cycles in the field, Hill first found 2nd-stage larvae on 26th May, but 3rd-stage larvae did not appear until 7th July, and 4th stage until 10th November, so that the completion of two of the four larval instars required more than five months, including the whole of the summer. This evidence suggests very strongly that *C. impunctatus* has only one generation a year.

In this connection, the recent work of Lawson and Downes should be considered. Lawson (private communication) has reared *C. scoticus* (one of the *C. obsoletus* group) in the laboratory from egg to adult in four weeks, under favourable conditions, and Downes (private communication) has had considerable success in rearing *C. nubeculosus* in the laboratory, also in about four weeks. There are three important differences between these experiments and the breeding of *C. impunctatus* in nature. Firstly, they were conducted on different species. Secondly, both the *C. scoticus* and the *C. nubeculosus* larvae were reared in a rich organic medium heavily contaminated with farmyard manure. Such a larval environment is very different from that of *C. impunctatus*, which is found in acid, bogland soils, poor in bases and in which the decay of humus is very much retarded. Thirdly, the temperature in the laboratory favours rapid development.

(iv) *General considerations and summary.*

Two definite facts have emerged from the foregoing discussion. It has been shown that there were sufficient 4th-stage larvae in the soil at the time of the first adult maximum to account for a full second period of adult abundance, and that direct observations on the life cycle of *C. impunctatus* by Hill (1947) show that there was only one generation at Liverpool in 1945 and 1946. Therefore *C. impunctatus* would be unique if it had one generation a year in Liverpool and two generations a year at Loch Lomond, 200 miles further north. Moreover, if *C. impunctatus* is capable of such rapid development, why should it restrict itself to two generations, confined to the middle of the *Culicoides* season, when those species of *Culicoides* which are known or suspected of having more than one generation occur throughout the whole midge season ?

Thus, although definite conclusion can be reached, the weight of the evidence is against *C. impunctatus* being bivoltine.

(c) *Is* C. impunctatus *a Single Taxonomic Unit ?*

One possible explanation of the bimodal seasonal distribution is that two separate taxonomic units are being confused under the name *C. impunctatus*.

To ascertain whether this was true, specimens were taken from the two maxima at Wester Bannachra Woods in 1948, the most prolific of the four areas. In order to obtain a representative sample, one female and at least one male were taken from the catch on the 6 ft. trap at each catching station during the first or second week of June, and the third week of July. The wings of the females and the genitalia of the males were removed and mounted in polyvinyl alcohol for examination. No differences were observed between the wing patterns of the two groups, and their mean wing lengths were 1·35 ± 0·06 mm. for the first group, and 1·31 ± 0·07 mm. for the second group. This difference is statistically insignificant ($P = 0{\cdot}2$). At a later date different samples from each group were examined for the number of spermathecae per female, but in each group there were two.

Nineteen male terminalia from group 1, and 14 from group 2 were examined, but all agreed with the description and figures of *C. impunctatus* given by Edwards (1939). Too much importance must not be attached to this agreement, because the male genitalia are very similar in all members of the *C. pulicaris* group, i.e. *C. pulicaris*, *C. p. punctatus*, *C. delta*, *C. halophilus* and *C. impunctatus*, so that it is unlikely that there would be striking differences between the male genitalia of two varieties of *C. impunctatus*, if they existed.

Two differences between *C. impunctatus* genitalia are given by Hill (1947), who writes, ". . . slight discrepancies between our description and that of Edwards, who draws the parameres with a curved tip and describes the tergite as without a notch," but Edwards does not actually describe the tergite of *C. impunctatus*. He writes, " Hypopygium very similar to that of *C. pulicaris*," and, under *C. pulicaris*, he describes the distal margin of the tergite as straight or slightly concave, but in his figure of *C. impunctatus* (fig. 60*c*) it is shown as notched. Hill attributes the differences in the parameres to the use of different mounting techniques.

Whilst there are no morphological differences to separate the adults from the two maxima, it is possible to achieve a separation which, for practical purposes, is almost complete. In 1948 the minimum catch of *C. impunctatus* between the two peaks occurs in the last week of June at the two Bannachra areas and Wester Bannachra Moorland, and in the third week of June at Wester Bannachra Woodland. At this minimum the population will consist of a mixture of adults from the two peaks, but, judging from the rapidity with which the adult population rises and falls, figs. 1, 2 and 3, the weeks before and after the minimum are likely to be almost pure. In order to avoid any bias, due to the corrections applied earlier, the sex ratios of the first and second maxima in 1948 have been calculated only for those catching stations with complete records. In 1949 it was not clear where the minimum should be placed, fig. 5—that is, whether it occurred in the fourth week of June or in the second half of July, and so calculations have been made for both positions.

It will be seen in Table IV that the first population contained about 10 per cent. more males than the second. There is variation in the sex ratio of the same population in different areas, so that the percentage of males in P_1 varies from 57·0 per cent. to 69·1 per cent., and in P_2 from 48·7 per cent. to 58·9 per cent., but an analysis of variance reveals that the difference between the populations is very highly significant ($P = 0{\cdot}001$), whilst that between the areas is only just significant ($P = 0{\cdot}05$). An estimate of the experimental error involved is obtained by comparing the 1948 and 1949 results for Bannachra Woodland. In 1948 P_1 contained 61·5 per cent. males, and in 1949 67·3 per cent. (or 68·3 per cent.), whilst P_2 had 49·1 per cent. males in 1948, and 50·0 per cent. (or 48·7 per cent.) in 1949. Thus the experimental error is reasonably small.

It is most unlikely that the higher proportion of males in P_1 has any substance in reality, but that on account of some particular feature of their behaviour, more males (or less females) are caught on the traps. It is possible that this difference may be due to changes in the habitat, for example the development of full foliage, etc., but this is hardly likely to apply to Wester Bannachra Moorland which, to the eye, appeared hardly to alter.

TABLE IV.—*Comparison of the Sex Ratios in the Two Seasonal Populations of* C. impunctatus.

In 1949 two stations in the moorland adjacent to Bannachra Woodland were also operated and have been included. The results are given for the alternative positions of the minimum in 1949. (*a*) = 4th week in June. (*b*) = 2nd half of July. In the analysis of variance 1949*a* was excluded. P_p and P_a are the probabilities that the differences between the populations and the areas were due to experimental error.

Area.	No. of stations.	Population No.	No. of adults.	Males. (%).	P_1–P_2. (%).
Wester Bannachra Moorland, 1948	6	P_1	1989	57·0	+ 8·2
		P_2	4655	48·8	
Wester Bannachra Woodland, 1948	2	P_1	2113	69·1	+10·2
		P_2	4848	58·9	
Bannachra Moorland, 1948	2	P_1	435	68·1	+10·2
		P_2	1109	57·9	
Bannachra Woodland, 1948	6	P_1	1237	61·5	+12·4
		P_2	1598	49·1	
Bannachra Woodland, 1949*a*	13	P_1	5810	68·3	+19·6
		P_2	718	48·7	
Bannachra Woodland, 1949*b*	13	P_1	6208	67·3	+17·3
		P_2	427	50·0	

$P_p = 0{\cdot}001 \quad P_a = 0{\cdot}05.$

A detailed analysis has been made of the vertical and horizontal distributions of the two populations (Kettle, 1950). It was found that the differences between the distributions of the two populations were too great to be attributed to experimental error. Therefore the two populations have similar but not identical spatial distributions.

In conclusion it can be stated that although there are no morphological differences between the populations they differ biologically in the following features: (i) in the times of their seasonal appearance, (ii) in their sex ratios, (iii) in their vertical and horizontal distributions. The two populations are therefore biologically distinct.

(d) *Comparison of Loch Lomond Results with those of Hill* (1947) *at Liverpool.*

If the bimodal seasonal distribution is normal for *C. impunctatus* in Scotland, how is it related to Hill's unimodal curve at Liverpool? Her results have been grouped in weekly intervals, corresponding with those of the observations recorded here, and the mean number of female *C. impunctatus* per collection per week inserted in fig. 4. Part of the differences between this curve and the others may be due to the different method of estimating the population density. (Hill estimated it by collecting on still evenings, all the *Culicoides* which alighted between two hours and one hour before sunset on a black cloth, 3 sq. ft. in area, hung on bushes at a height of 4–5 ft.).

At Liverpool the season of the female *C. impunctatus* begins at about the same time, or perhaps a week earlier than at Loch Lomond, but the peak occurs about two weeks later than the Loch Lomond first peak, and five weeks earlier than the second. Finally, the Liverpool season ends two or three weeks earlier. Whilst there is no trace of a second peak at Liverpool, it can hardly be said that Hill's curve fits the Loch Lomond first peak and, indeed, no amount of ingenious shifting of the distributions produces even a reasonable amount of agreement. It is as if two totally different distributions were being compared. Therefore, if it is agreed that *C. impunctatus* is composed of two biological races at Loch Lomond, then logically Hill's data are evidence for the existence of a third race at Liverpool. Such a conclusion may appear extravagant, but at the moment no simpler solution can adequately explain all the facts.

4. SUMMARY.

It has been shown that the seasonal distribution of *C. impunctatus* at Loch Lomond in 1947, 1948 and 1949 was bimodal. Such a distribution could be due to three possible causes:

1. To climatic factors.
2. To *C. impunctatus* being bivoltine.
3. To *C. impunctatus* consisting of two races.

The consideration of the climatic factors led to the conclusion that, whilst they might considerably modify the bimodal distribution, they could not, in themselves, account for it.

The evidence for and against *C. impunctatus* having two generations a year was not conclusive. Nevertheless, at the end of May, when nearly all the individuals of the first population had pupated, the larval density was still more than half its initial value, so that there were sufficient larvae present in the soil to account for a full second period of emergence, without the necessity of postulating a rapidly developing generation. Also Hill's (1947) data on the length of time required to complete various parts of the life cycle in the summer at Liverpool demonstrate that *C. impunctatus* is a slowly growing creature, incapable of the necessary rapid development. In addition, *C. impunctatus* would be unique were it bivoltine in Scotland and univoltine 200 miles further south, in England. Therefore, although incomplete, the evidence weighs heavily against *C. impunctatus* being bivoltine.

Critical examination of the pattern and length of the wings of females and the genitalia of male *C. impunctatus* failed to reveal any morphological differences between the adults of the two populations. However, there was a statistically highly significant difference between the sex ratios of the two populations, the first containing about 10 per cent. more males than the second. Also, the two populations have similar but statistically different vertical and horizontal distributions. These facts, in addition to the larval results quoted above, are sufficient to justify the acceptance, as a working hypothesis, of the existence of two biological races of *C. impunctatus* at Loch Lomond.

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This work was done whilst I was employed as Entomologist to the Sub-Committee on Midge Control, Scientific Advisory Committee, Department of Health for Scotland. I should like to thank members of the Sub-Committee for their constant support.

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THE NEW ZEALAND PSYCHODIDAE: A STUDY BASED UPON THE COLLECTION AND MANUSCRIPT NOTES OF THE LATE DR. A. L. TONNOIR.

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Manuscript received 12th October, 1949.

(Read 3rd May, 1950.)

With 23 Text-figures.

Our knowledge of the family Psychodidae in New Zealand is extremely meagre. Hutton (1881) described a species of *Psychoda*, *Ps. conspicillata*, which Tonnoir (1934) has shown to be the cosmopolitan *Ps alternata* Say. Tonnoir (1920) described a semi-apterous species of *Psychoda*, *Ps. acutipennis*, from the Bounty Islands, 490 miles east of New Zealand. Hutton (1901) described two species of *Pericoma*, *P. funebris* and *P. varigata*, which Tonnoir (1934) has shown to be one and the same species, the former name having page priority. Alexander (1921) described a species of *Nemopalpus*, *N. zealandica*, from the wing only, further details being given by Tonnoir (1922, 1940). From these accounts it would appear that the Psychodid fauna of New Zealand is singularly sparse, a feature which would contrast with the abundance of the related family Tipulidae. In this paper, however, it will be shown that such is not the case, the Psychodid fauna being abundant and varied.

During his stay in New Zealand the late Dr. A. L. Tonnoir made an extensive collection of Psychodidae, and from time to time wrote notes upon his material. It is clear that he intended to publish an account of the New Zealand representatives of this family, and was only prevented from doing so by his death in 1940. Through the kindness of Dr. David Miller, of the Cawthron Institute, I have been entrusted with the collection and manuscript notes of Dr. Tonnoir. I had at first hoped to be able to publish the notes as they stood, but they represent only rough accounts of the species and would undoubtedly have needed considerable revision before publication. In no case is it possible to use them without making some alterations. I have therefore worked through the collection from the beginning and described all the new species myself. I wish, however, to acknowledge my great indebtedness to the late Dr. Tonnoir, not only for the magnificent collection, but for the many features and ideas which have been brought to my notice by a study of his manuscript notes. In this paper twenty-seven new species are described, and an additional forty or so await description until more material can be obtained. Dr. Tonnoir had proposed names for all but five of these species; in some cases these have been retained and will be acknowledged in the text. In other cases they have been abandoned. The receipt of material from other collections, notably the Canterbury Museum, Christchurch, and the British Museum, has shown that in New Zealand, particularly in the genus *Pericoma*, there are groups of species having identical wing patterns and coloration, and differing only in the genitalia. In such cases I have replaced names indicative of body colour or pattern, by ones indicating some specific character of the genitalia. The great majority of the specimens in the cabinet have been collected by Dr. Tonnoir, but some have been presented by other entomologists. Only in the latter case will explicit mention of the collector's name be made; when localities are given with no mention of the collector it is to be taken that the specimen was collected by Dr. Tonnoir. Unless it is otherwise stated all the material is in the Tonnoir collection and will ultimately be returned to the Cawthron Institute, Nelson.

Genus *Trichomyia* Haliday.

Trichomyia fusca sp. n.

A uniformly brownish species, differing but little (except for the genitalia) from the genotype *T. urbica* Curtis.

♂♀. Wing length 3 mm.

♂. Integument of head and abdomen dark brown, of thorax, legs and genitalia yellowish-brown; vestiture of sparse, long, dark brown hairs with a golden reflection. Antenna projecting beyond abdomen in pinned specimen, basal flagellar segment cylindrical, seven to eight times as long as width at middle, remaining segments except the last subequal, two-thirds length of basal flagellar segment (fig. 1A); terminal segment small, ovoid, one-quarter length of preceding one (fig. 1B), ascoids long, straight rods in pairs on segments 3–15. Maxillary palpi with first segment half as long again as wide, next three segments subequal, about twice as long as first.

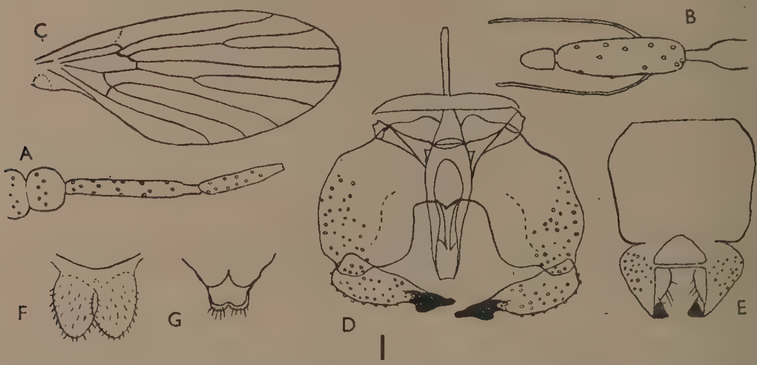

Fig. 1.—*Trichomyia fusca* sp. n. A, Base of, and B, tip of, antenna; C, venation; D, coxite, style and aedeagus; E, 9th tergite with appendages; F, ovipositor; G, subgenital plate.

Wing venation (fig. 1C) similar to that of genotype, except that cross vein M-Cu is placed at forking of M_3-M_4, not before it; in this it agrees with the South American *T. edwardsii*, but differs from that species in having Cu not so long, ending before the level of the anterior fork.

Hypopygium (fig. 1D and E): Coxite rounded externally, flattened to form a shelf-like inner margin bordering the aedeagus; style short, narrowed in distal third to terminate in heavily sclerotized chisel-like blade; 9th tergum ending in paired unarticulated blades separated by a deep incision; aedeagus simple, symmetrical, shaped like a scoop, more strongly sclerotized in the lateral margins.

♀. Similar to male generally, but antennae slightly shorter, ascoids shorter; ovipositor consisting of two oval lamellae fringed with hairs (fig. 1F); subgenital plate bilobed and hairy (fig. 1G).

Type.—Allotype, 4 ♂, 4 ♀ paratypes from Aniseed Valley, 1–4.xii.1923.

Other specimens.—5 ♂ with type and allotype, 7 ♂, 4 ♀, from Upper Maitai Valley, Nelson, 20.xii.1932, 2 ♂ from Nelson, 28.xi.1923, and 1 ♀ from Nelson, 9.iii.1922.

One of the males from the type locality is deposited in the collections of the Canterbury Museum, Christchurch; the others are in the Tonnoir collection. The name adopted for this species was proposed by Tonnoir in his manuscript notes.

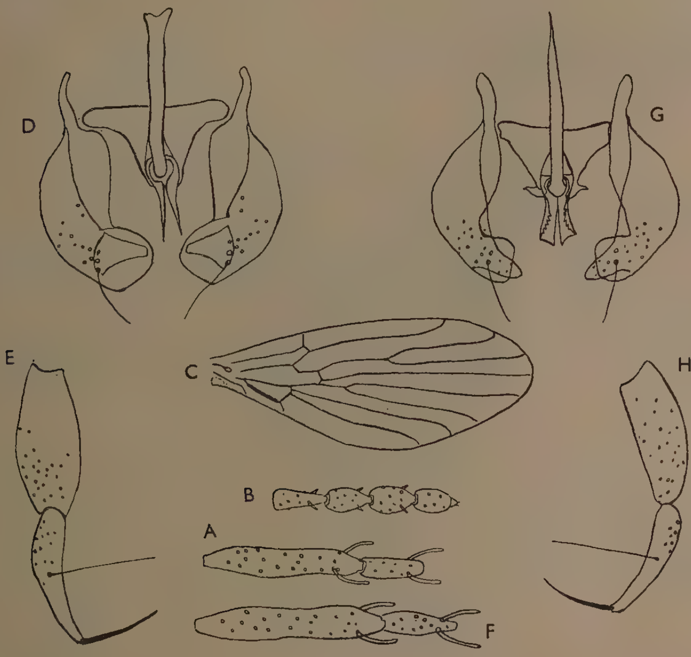

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Fig. 2.—A–E, *Sycorax cryptella* sp. n.; F–H, *Sycorax impatiens* sp. n. A, F, Basal flagellar segments of antenna; B, tip of antenna; C, venation; D, G, cercopods with aedeagus; E, H, forceps. A and B drawn from a paratype ♀.

Genus *Sycorax* Haliday.

Sycorax cryptella sp. n.

A small luteous species with elongate forks.

♂♀. Wing length, 1·8 mm.

♂. General coloration of integument and vestiture luteous. Antenna with first segment of flagellum two and one-third times as long as the succeeding one (fig. 2A); segments gradually diminishing in length, obconical except for the last three, which are ovoid (fig. 2B); terminal segment with a small conical apiculus; ascoids simple, colourless, digitiform hairs in pairs on segments 3–10; on each of segments 6–9 is a single, pointed, cone-like sensilla, and on segments 10–14 paired cones are present. Palpi with subequal ovoid segments, the terminal one narrower than the preceding three. Wing (fig. 2C) oval; apex between tips of R_3 and R_{4+5}; R_3 distinctly longer than stem of radial fork, which is behind tip of M_4; first basal cell about one-third length of wing.

Hypopygium; forceps with coxite as long as style (fig. 2D), the spine of the latter slightly more than half its length; cercopods as shown in fig. 2E, with tip bearing a ventral semicircular lobe and a dorsal more sclerotized process; aedeagus terminating in two stout pointed processes.

♀. Wing slightly longer and narrower; otherwise similar to male apart from the bilobed ovipositor.

Type (head missing), allotype, Nelson, 1.x.1923.
3 *paratypes*, Nelson, 18.x.1923.
I have adopted Tonnoir's manuscript name for this species.

Sycorax impatiens sp. n.

Very similar to *S. cryptella*, the coloration and neuration being identical.

♂♀. Wing length, 1·8 mm.

♂. Antenna with first flagellar segment two and one-half times as long as the succeeding one (fig. 2F); segments obconical, gradually decreasing in length, the last two ovoid, terminating in a conical apiculus; ascoids insufficiently visible in type to be described.

Wing venation as in *S. cryptella*.

Hypopygium; forceps (fig. 2G) with coxite as long as style, the spine of the latter two-thirds of its length; cercopods as shown in fig. 2H, differing from those of *S. cryptella* only in the dorsal, more sclerotized process being rather longer. Aedeagus terminating in two inrolled valves, the dorsal margins of which are toothed.

♀. Similar to male apart from the bilobed ovipositor.

Type and *allotype*.—Otira, 10.ii.1922.
Paratype ♂ and ♀.—Dun Moutain, 3000 ft., 5–7.i.1922. 5 ♀ paratypes, Lake Brunner, 4.ii.1922.
I have adopted Tonnoir's manuscript name for this species.

Sycorax dispar sp. n.

A luteous species with brownish abdomen, characterized by the reduction of the radial forks.

♂♀. Wing length 1·6 mm.

♂. General coloration luteous, abdomen brownish; antennae with first flagellar segment only longer by one-fifth than the succeeding one (fig. 3A); segments obconical, gradually diminishing in size, terminal segment ovoid, with a conical apiculus (fig. 3B); ascoids insufficiently visible on type to be described. Palpal segments subequal, the second with a transverse row of sensillae on it.

Venation; wing missing from type, details taken from a male paratype. R_3 distinctly shorter than stem of radial fork, which is anterior to tip of M_4; first basal cell about four-tenths length of wing (fig. 3C).

Hypopygium; forceps short, with coxite as long as style (fig. 3D), the spine of the latter two-thirds of its length; cercopods as shown in fig. 3E, with tips bent through a right angle and a warty area bearing hairs laterally; aedeagus subcylindrical, four times as long as broad.

♀. Similar to male apart from bilobed ovipositor.

Type, allotype and *paratype* ♂, Nihotapu, 23.ii.1923.

I have adopted Tonnoir's manuscript name for this species.

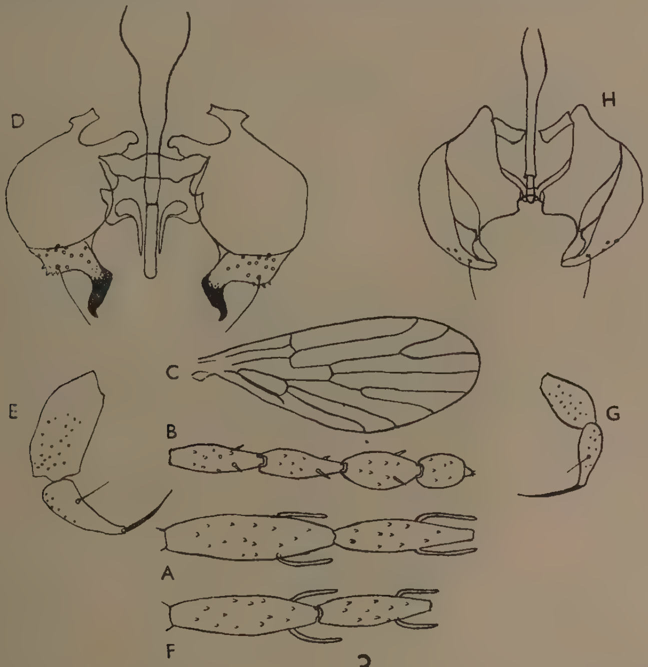

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FIG. 3.—A–E, *Sycorax dispar* sp. n.; F–H, *Sycorax milleri* sp. n. A, F, Basal flagellar segments of antenna; B, tip of antenna; C, venation; D, H, cercopods with aedeagus; E, G, forceps. C drawn from a paratype ♂.

Sycorax milleri sp. n.

Very similar to the previous species, but more luteous and with different genitalia.

♂. Wing length 1·5 mm.

♂. Coloration luteous; antenna with first flagellar segment longer by two-fifths than succeeding one (fig. 3F), segments obconical, gradually decreasing in size, the last one ovoid, with a conical apiculus; ascoids insufficiently visible on type to be described. Palpal segments ovoid, subequal, the second with a curved, rather thick, sensilla on one side.

Venation very similar to that of *S. dispar*, the radial fork being even nearer the wing margin.

Hypopygium; forceps (fig. 3G) with coxite a little longer than style, the terminal spine of the latter a little longer than the style itself; cercopods as shown in fig. 3H, with a ventral semicircular lobe and a dorsal more sclerotized process; aedeagus cylindrical, short, scarcely twice as long as wide.

Female unknown.

Type.—Days Bay, 29.xi.1921.

Paratype male, Nelson, 15.xii.1921.

Tonnoir has suggested this species name in his manuscript notes, as a token of his indebtedness to Dr. David Miller, of the Cawthron Institute; an indebtedness of which I am equally conscious.

Genus *Pericoma* Walker.

Pericoma funebris.

Pericoma funebris Hutton, 1901. *Trans. N.Z. Inst.* **34** : 180.
= *Pericoma varigata* Hutton, 1901. *Ibid.*

Tonnoir (1934) has already shown, by an examination of the types of these two species, located in the Canterbury Museum, Christchurch, that they are the same species, the former name having page priority. No further description of them has been published however, since Hutton's inadequate account (1901), so a brief description, based on the series of excellent specimens in the Tonnoir collection, will be given.

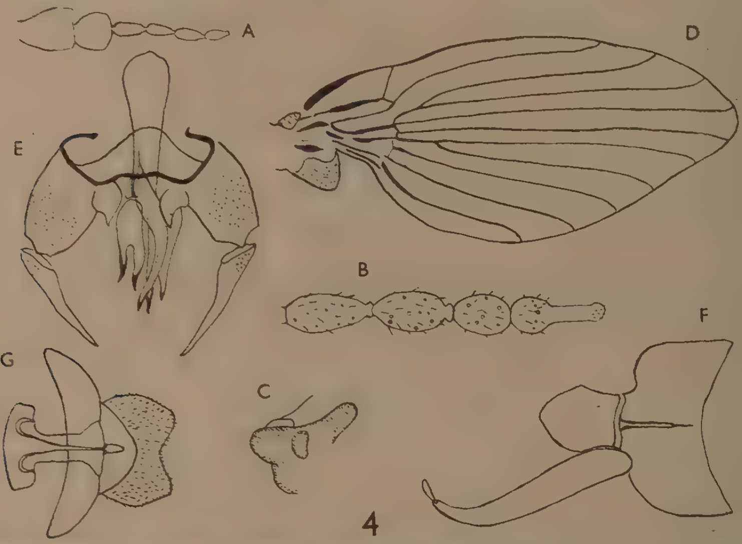

Fig. 4.—*Pericoma funebris* Hutton. A, Base of, and B, tip of, antenna; C, thoracic display organ; D, venation; E, coxite, style and aedeagus; F, cercopods, anal valve and 9th tergite; G, subgenital plate.

The largest known species in the genus, brownish black, with a sooty-black patch in the centre of the wing disc and marginal white dots.

♂♀. Wing length 4 mm.

♂. Covering of head black, eyes well separated; antennae slightly more than half width of wing, flagellar segments fusiform (fig. 4A), gradually diminishing in size, the last with an apiculus twice as long as the basal bulb (fig. 4B); first segment with black scales, second segment with whitish scales. Palpal formula 17 : 18 : 16 : 20.

Vestiture of thorax velvety-black with a yellowish transverse band just in front of wing base, and a white tuft on underside of wing base; paired rounded protuberances (fig. 4C), presumably organs of erotic display, above anterior spiracle. Wings broad, almost triangular in outline (fig. 4D), Sc strongly developed and clearly jointed to costa; forks very near wing base, posterior fork past anterior one; origin of stem of R_{2+3} at apex of first basal cell, which is only slightly longer than the second basal cell. Vestiture of wing dark brown with a bronzy reflection; numerous erect white hairs scattered along the veins in basal third; a tuft of erect white hairs two-thirds way along each vein except R_1, R_5 and M_4, a row of erect sooty-black hairs proximal to each tuft, combining to give the effect of a central black spot on the wing; a second row of white tufts occurring behind each vein tip; those on the anterior margin being incurved and overlying the wing membrane, those on the posterior margin overlying the fringe; tufts behind R_3, R_4 and R_5 very small, whilst those behind M_1 and M_3 the largest; wing fringe dark apart from a few longer whitish hairs at the tip.

Legs with a dark brown covering and white apical rings on tibiae and first and second tarsal joints; second tarsal joint white dorsally.

Hypopygium; coxite (fig. 4E) subcylindrical, style tapering, only slightly swollen at base; aedeagus of a complex structure, consisting of a single dorsal process with one long side tooth, two processes placed more laterally, each bearing two curved pointed teeth, and two subtriangular pieces somewhat curved outwards and fused to the inner faces of the coxites. Cercopod (fig. 4F) gently tapering, not swollen at base, considerably longer than 9th tergite, with a single retinaculum; anal valve (10th tergite) rounded apically.

♀. Differs from male in coloration of thorax, which has mainly greyish-white hairs on it, in the absence of the white tuft at the wing base and of the display organ above the spiracle, and in the presence of a white tuft above the ovipositor. Subgenital plate as in fig. 4F.

Type.—Canterbury Museum, Christchurch, Hutton, 1901.

As the female was unknown to Hutton, one of the specimens in the Tonnoir collection has been used for the above description.

Allotype.—Nelson, 23–26.xi.1923 (*E. Gourlay*).

Other specimens.—10 ♂, 1 ♀, Upper Maitai Valley, Nelson, 20.xii.1932. 3 ♀, Wellington, 1.xii.1921. 1 ♂, 2 ♀, Aniseed Valley, 1–4.xii.1923. 1 ♂, 1 ♀, Maitai Valley, Nelson, 10.ii.1924 (*A. Philpott*). 3 ♂, Wellington Botanical Gardens, 2.ii.1922 (*J. Myers*).

Pericoma multimaculata sp. n.

A rather large, dark brown species with the legs ornamented, some white spots on the wing disc, and the fringe completely dark.

♂♀. Wing length 3½ mm.

♂. Head with dark brown vestiture; eye bridges separated by the width of three facets; antennae just equal to width of wing, flagellar segments fusiform, gradually diminishing in size (fig. 5A), the last one with a club-shaped apiculus one and one-half times as long as the basal bulb (fig. 5B). Palpal formula 13 : 19 : 17 : 23.

Thorax and abdomen with greyish-brown vestiture, no special display-organ present. Wing (fig. 5C) broadly oval, Sc well developed, not reaching costa; both forks very near to base of wing, the posterior past the anterior; basal cells almost equal, origin of stem of anterior fork at apex of first basal cell; vestiture of wing dark brown, apart from erect hairs which are reddish-brown; a patch of white erect hairs in centre of R_1, extending on to costa anteriorly, and radial fork posteriorly; a tuft of white erect hairs at the end of each row of dark erect hairs, except on veins R_1, R_5 and M_4, where erect hairs are absent;

fringe uniformly dark. Legs dark brown; tip of tibia and first tarsal joint, and whole of second tarsal joint, white dorsally.

Hypopygium; coxite (fig. 5D) about twice as long as broad, style elongate, straight, only slightly swollen basally; aedeagus complicated, composed of five structures, an angulated piece narrowed terminally like the bow of a canoe and clearly jointed to the rest of the aedeagus, a long curving portion hooked at the tip, two pieces with broad bases narrowing to their extremities, and a small, upwardly-pointing, curved, pointed element. Cercopod swollen in basal half, retinaculum single (fig. 5E); anal valve of characteristic shape.

♀. Similar to male; subgenital plate as in fig. 5F.

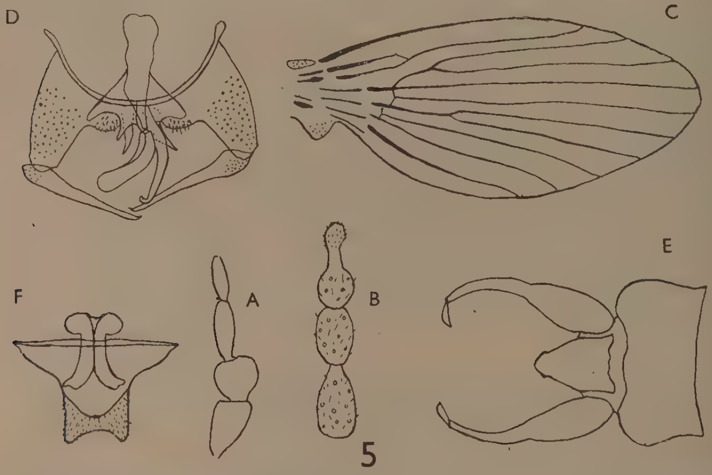

Fig. 5.—*Pericoma multimaculata* sp. n. A, Base of, and B, tip of, antenna; C, venation; D, coxite, style and aedeagus; E, cercopods, anal valve and 9th tergite; F, subgenital plate. A, B, C and F from allotype; D and E from a paratype ♂.

Type, allotype, 4 ♂, 5 ♀ *paratypes,* Waiho, 17–19.i.1922. 1 ♂ paratype, Lake Brunner, 4.ii.1922.

Other specimens.—4 ♂, Lake Brunner, 4.ii.1922. 1 ♂, Mt. Arthur, ?.xii.1928 (*A. Philpott*). British Museum collection, 2 ♀, Ohakune, ?.xi.1922 and ?.v–vii.1923 (*T. R. Harris*).

Tonnoir had proposed two names for this species, that on the specimens being different from that in the manuscript notes. I have adopted the one on the specimens. One of the female paratypes is in the collections of the Canterbury Museum, Christchurch.

The following three species are all very alike superficially, having similar wing patterns and coloration. They differ greatly in their genitalia however.

Pericoma triuncinata sp. n.

A small brownish species with mottled wings and white metatarsi.

♂♀. Wing length 2 mm.

♂. Vestiture of head greyish; eye bridges separated by a distance equal to width of one facet; antenna scarcely equal to width of wing; flagellar segments cask-shaped (fig.

6A), the 15th subspherical, the 16th with a club-shaped apiculus slightly shorter than the basal bulb (fig. 6B). Palpal formula 5 : 6 : 8 : 13.

Thoracic vestiture white, with darker, brownish hairs interspersed, especially between the wing bases; wing with both forks at same level, a little before the tip of Cu, origin of anterior fork at apex of first basal cell, which is considerably longer than the second; wing membrane infuscated as shown in fig. 6C; wing vestiture light brown, with darker tufts of erect hairs at base of Cu, on each fork, and at apex of first basal cell; a transverse row of tufts of dark reclinate hairs extending across the wing from tip of R_1 to M_4, giving the appearance of a dark fascia, and tufts of white reclined hairs occurring distal to it, on R_2, R_3, M_1, M_2 and M_3; a dark tuft at the top of each vein; fringe brown, with two whitish spaces, one around tip from R_2 to M_2, and the other at M_4. Legs with femora and tibiae greyish with apical rings of white, the latter brownish subapically; metatarsi white, the rest brown.

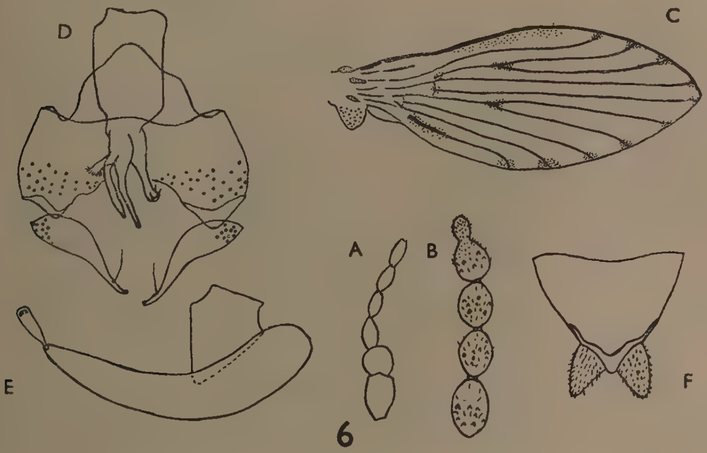

FIG. 6.—*Pericoma triuncinata* sp. n. A, Base of, and B, tip of, antenna; C, venation; D, coxite, style and aedeagus; E, cercopod and anal valve; F, subgenital plate.

Hypopygium; coxite (fig. 6D) slightly longer than wide; style tapering rapidly to a slender curved tip bearing a prominent preapical seta; aedeagus with four processes, one curved upwards and ending in a trifid claw, two angulated median pieces, one a little longer than the other, and a fourth fan-like short piece, largely obscured by the other two; cercopod evenly tapered, with a single retinaculum; anal valve markedly triangular (fig. 6E).

♀. Similar to male; subgenital plate as in fig. 6F.

Type, Aniseed Valley, 1–4.xii.1923.

Allotype.—Mt. Arthur table land, 24.xii.1921. 2 ♂ and 2 ♀ paratypes with allotype, 1 ♂ paratype with type. 1 ♂, 1 ♀ paratype, Dun Mountain, 5–7.i.1922 1 ♂ paratype, Waiho, 28.i.1922.

Other specimens.—2 ♂, Dun Mountain, 5–7.i.1922. 6 ♂ with allotype, 1 ♂, Upper Maitai Valley, 20.xii.1932.

Pericoma claviata sp. n.

Differing from *P. triuncinata* in having rather more brown hairs in the thoracic vestiture and in having the wing pattern more contrastedly coloured.

♂. Wing length 2·4 mm.

♂. Vestiture of head whitish ; eye bridges separated by width of three facets ; antennae four-fifths of width of wing, flagellar segments cask-shaped (fig. 7A), terminal one with a club-shaped apiculus equal to the basal bulb ; some whitish scales on the base of the antenna. Palpal formula 8 : 7 : 9 : 17.

Thoracic vestiture whitish with a transverse band of brown hairs interspersed with whitish ones just anterior to wing bases, and a tuft of dark brown hairs between wing bases. Wing shape and venation similar to previous species but anterior fork distinctly past posterior one (fig. 7B) ; pattern of dark brown and white hairs also similar, but the apical white space in the fringe extending only from R_3 to R_5. Legs greyish, femorae tipped at apex with white, tibiae brown subapically, with an apical white ring, metatarsi completely white, rest of tarsi brown.

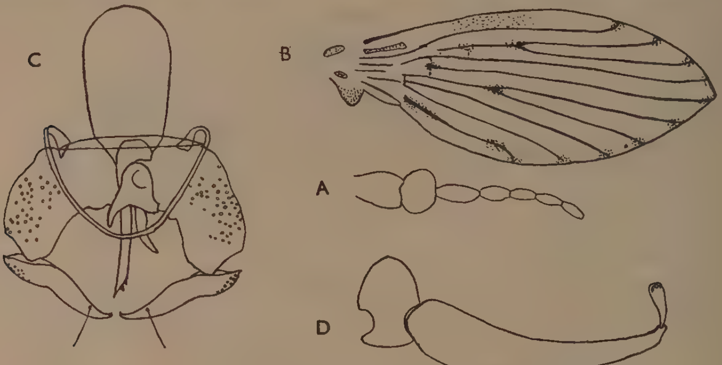

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Fig. 7.—*Pericoma clavata* sp. n. A, Base of antenna ; B, venation ; C, coxite, style and aedeagus ; D, cercopod and anal valve. A, drawn from a paratype ♂.

Abdomen with brown vestiture.

Hypopygium ; coxite (fig. 7C) longer than broad, style short and thick with a preapical seta ; aedeagus composed of three pieces, one very long and straight and notched at the end, a second broadly triangular with a curved pointed tooth, and a third longer, pointed, and narrowing in the distal third ; cercopod very long and evenly tapered (fig. 7D), with a single retinaculum ; anal valve rounded and short.

Female unknown.

Type and 7 ♂ *paratypes*, Lake Moana, 16–21.xii.1925.

The eight specimens on which this description is based were collected by Tonnoir and left unnamed in the collections of the Canterbury Museum, Christchurch, to which they will be returned.

Pericoma drepanata sp. n.

Very similar to *P. triuncinata*, but the wing pattern is much less contrasty, and there are fewer white hairs in the wing.

♂♀. Wing length 2·5 mm,

♂. Vestiture of head pale brown, eyes separated by a distance of one and a half facets; antennae scarcely equal to width of wing; basal flagellar segments cask-shaped, the 15th spherical, the last with a club-shaped apiculus longer than the basal bulb (fig. 8A). Palpal formula 4·5 : 7 : 8 : 14.

Thorax with brownish vestiture; wing venation and shape as in *P. triuncinata* except that the origin of R_{2+3} is well past apex of first basal cell; vestiture brownish with darker spots and a central dark fascia as in *P. triuncinata*; but with much less contrast between the ground colour and the darker markings; white tufts of reclined hairs distal to central dark fascia absent; fringe white from R_3 to M_2 and again at M_4. Legs brownish with white apical rings on tibiae, and white metatarsi.

Hypopygium; coxites (fig. 8B) similar to *P. triuncinata*, but style rather more blunt and distal tapering portion shorter; aedeagus quite distinct, consisting of two curved pointed processes; the longer and more curved one lying dorsally and facing the other like the two blades of a pair of callipers; an apparent third process, much smaller than the other two, is a curved continuation of the larger of the two main processes; cercopod evenly tapered with a single retinaculum; anal valve pointed (fig. 8C).

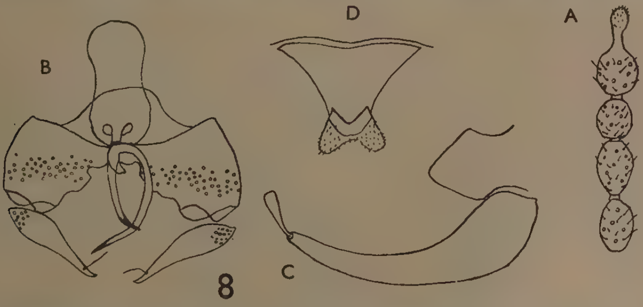

FIG. 8.—*Pericoma drepanata* sp. n. A, Tip of antenna; B, coxite, style and aedeagus; C, cercopod and anal valve; D, subgenital plate.

♀. Similar to male; subgenital plate as in fig. 8D.

Type, allotype, 4 ♂, 3 ♀ *paratypes,* Mt. Arthur, 24–28.xii.1921. ♀ paratype, Otira, 10.ii.1922.

Other specimens.—4 ♂ with type. ♀ Otira, 10.ii.1922.

Pericoma maura sp. n.

A rather small, completely brownish-black species, with the anterior fork somewhat before the posterior one, and the legs completely black.

♂♀. Wing length 2·1 mm.

♂. Eye bridges separated by a distance equal to width of two facets; antennae scarcely as long as width of wing, flagellar segments very short and fat (fig. 9A), last three spherical, the terminal one with a club-shaped apiculus almost twice as long as the basal bulb (fig. 9B). Palpal formula 5·5 : 8 : 9 : 15.

Thorax with brownish-black vestiture; wing (fig. 9C) with origin of stem of anterior fork placed on R_5 at a distance from apex of first basal cell equal to width of cell; second basal cell distinctly shorter than first; posterior fork past anterior fork, at a level just before tip of Cu. Vestiture of wing uniformly dark without white tufts on disc or margin; erect hairs present on all veins, though limited to base of R_5 and M_4; extending to tip on

R_1 and Cu, and to this level on the other veins except on R_3, where they cease half-way along. Legs uniformly brown.

Hypopygium ; coxite (fig. 9D) slightly longer than broad, style swollen at base ; tip outwardly curved, bearing a preapical seta ; aedeagus complex, consisting of a median, straight blunt process, swollen proximally, a slightly curved pointed process, and two lateral pointed pieces embracing the median ones ; cercopod (fig. 9E) long and regularly curved, with a single retinaculum ; anal valve as in fig. 9F.

♀. Similar to male ; subgenital plate as in fig. 9G.

Type, allotype and 4 ♂ *paratypes.*—Aniseed Valley, 1–4.xii.1923.

I have adopted Tonnoir's manuscript name for this species.

The next four species belong to a complex of species all of which are very similar and are characterised by having a completely golden vestiture and very similar wing venation. The four described here are probably only a small fraction of the number that will eventually be described, and I have isolated specimens of at least another six species. It is impossible to identify members of this complex without making a microscope preparation of the genitalia.

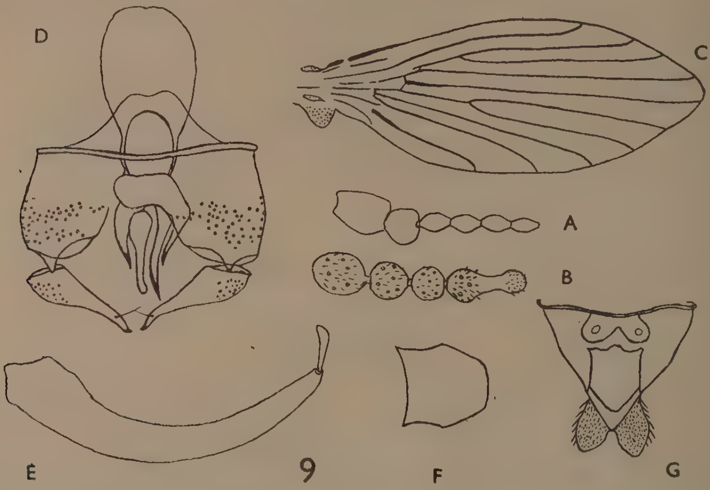

FIG. 9.—*Pericoma maura* sp. n. A, Base of, and B, tip of, antenna ; C, venation ; D, coxite, style and aedeagus ; E, cercopod ; F, anal valve ; G, subgenital plate.

Pericoma lobisterna sp. n.

♂♀. Wing length 2·8 mm.

♂. Eye bridges separated by width of three facets ; antennae scarcely as long as width of wing ; first segment one and one-quarter times as long as broad, the basal flagellar segments fusiform, three times as long as wide (fig. 10A), diminishing gradually so that the terminal one is half as long again as wide, with a club-shaped apiculus as long as the basal bulb (fig. 10B). Palpal formula 6 : 11 : 12 : 19.

Thorax covered with a golden vestiture ; wing (fig. 10C) with two forks both well before tip of Cu, the posterior fork a little past the anterior one ; origin of stem of anterior fork at apex of first basal cell, which is equal in length to second basal cell ; vestiture uniform golden except for a slightly darker fascia on the anterior and posterior margins, only visible when tilted in certain positions ; rows of erect hairs absent on R_1, R_5 and M_4 ; on R_2 extending to the level of the tip of R_1, on R_3 and R_4 a little further ; on the branches of M gradually receding from this level, and reaching the tip on Cu.

Hypopygium ; coxite longer than wide, without infrabasal process ; 9th sternite (fig. 10D) bilobed ; style gradually tapering with long sensory seta on last third ; aedeagus with two slightly curved pieces, one more pointed than the other and attached basally to membranous lobes ; cercopod evenly tapered with a single retinaculum ; anal valve as in fig. 10E.

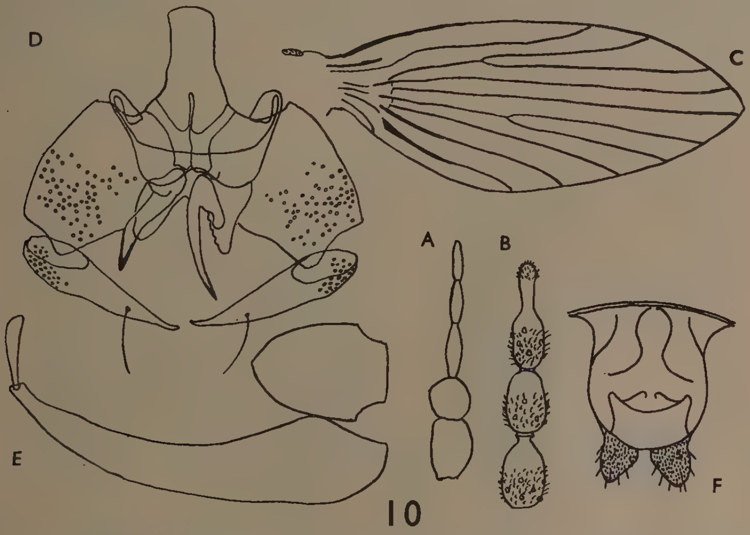

FIG. 10.—*Pericoma lobisterna* sp. n. A, Base of, and B, tip of, antenna ; C, venation ; D, coxite, style and aedeagus ; E, cercopod and anal valve ; F, subgenital plate.

♀. Similar to male ; the subgenital plate as in fig. 10F, the two lobes separated and somewhat triangular.

Type and *allotype*.—Flora River, Mt. Arthur, 12.i.1922 (*A. Philpott*). 2 ♂, 1 ♀, paratypes, with type (*A. Philpott*).

Paratypes.—Nelson, ♂, 15.xii.1921 ; ♀, 4.iii.1922 ; 2 ♀, 8.xii.1921. 2 ♂, Upper Maitai Valley, 20.xii.1932.

Other specimens.—5 ♂, Upper Maitai, 20.xii.1932. ♂, Days Bay, 29.xi. 1921. ♂ Nihotapu, 24.ii.1923. ♀, Te Aroha, 1.iii.1923. 2 ♀, Nelson 4.iii.1922 and 15.xii.1921. ♀, Dun Mountain, 2.i.1933. ♀, Aniseed Valley, 1–4.xii.1923.

Pericoma bifalcata sp. n.

♂♀. Wing length 2·5 mm.

♂. Eye bridges separated by a distance equal to width of one and one-half facets ; antennae scarcely as long as wing width, 1st segment one and one-quarter times as long as wide ; flagellar segments very short and fat, the basal ones not more than twice as long as wide (fig. 11A), gradually diminishing, so the last two are subspherical; terminal one with a club-shaped apiculus as long as the basal bulb (fig. 11B). Palpal formula 5·5 : 9 : 11 : 17.

Thorax covered with a golden vestiture; wing with two forks nearer the base than in previous species (fig. 11C), the posterior fork past the anterior one and at about the level of the middle of Cu; vestiture and distribution of hairs as in previous species except that there is no trace of a dark marginal fascia.

Hypopygium; 8th sternite (fig. 11D) strap-like, not divided into lobes, coxite with an infrabasal process, as shown in fig. 11D, style short, tapering to a point, aedeagus composed of two sickle-shaped processes, one sharply, one bluntly pointed; cercopod long, evenly tapered, with a short broad retinaculum; anal valve pointed (fig. 11E).

♀. Similar to male; subgenital plate with triangular lobes just touching in centre (fig. 11F).

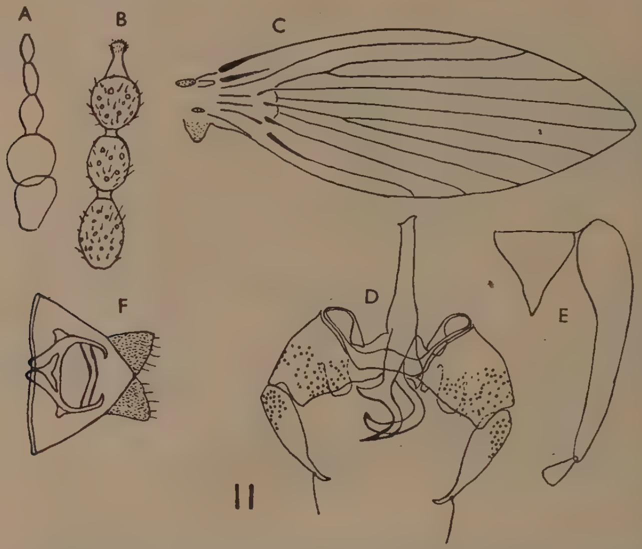

FIG. 11.—*Pericoma bifalcata* sp. n. A, Base of, and B, tip of, antenna; C, venation; D, coxite, style and aedeagus, some details of style added from a paratype; E, cercopod and anal valve, drawn one-fifth smaller than D; F, subgenital plate.

Type, allotype, 4 ♂ and 2 ♀ *paratypes.*—Mt. Arthur, 24.xii.1921. 2 ♀ paratypes, Nelson, 15.xii.1921.

Other specimens.—3 ♂, 3 ♀, Nelson, 28.xi.1923, 15.xii.1921, 29.x.?, 15.xii.1921, 9.x.1923, 30.xii.1921. 8 ♂, 11 ♀, Upper Maitai Valley, 20.xii.1932. 2 ♂, Dun Mountain, 5–7.i.1922; 1 ♂, 8 ♀, 2.i.1933. ♂, Aniseed Valley, 1–4.xii.1923. ♂, Weltons Bush, 2.xii.1921. ♂, Otira, 9.ii.1922. ♂, with type.

Pericoma gourlayi sp. n.

♂♀. Wing length 2·7 mm.

♂. Eye bridges separated by width of one and one-half facets; antennae slightly shorter than width of wing; basal flagellar segments fusiform, twice as long as wide (fig. 12A), gradually diminishing so that last two are subspherical, the apical one with a club-shaped apiculus longer than the basal bulb (fig. 12B). Palps unusually long, three-quarters length of antennae; palpal formula 6 : 10 : 12 : 17.

Thorax with whitish-golden vestiture; wing with stems of forks slightly longer than in previous species; vestiture golden yellow, with erect hairs whitish. Legs with a vestiture of whitish hairs.

Hypopygium; 9th sternite very deep (fig. 12C), coxite longer than broad without any infrabasal process; style as in related species with a long preapical seta; aedeagus composed of three pieces, the dorsal two being thick and rounded apically, the ventral one thin and pointed; cercopod (fig. 12D) evenly tapered with a single retinaculum; anal valve triangular and rounded at the tip.

♀. Covering of body not quite as white as in male; subgenital plate constricted at base, the lobes divergent (fig. 12E).

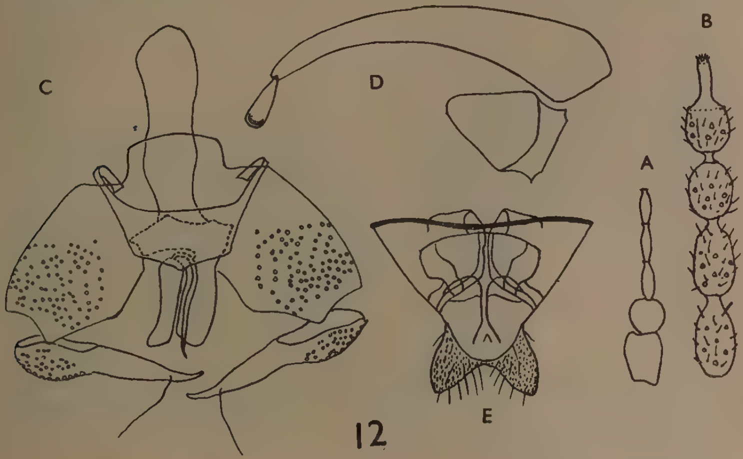

FIG. 12.—*Pericoma gourlayi* sp. n. A, Base of, and B, tip of, antenna; C, coxite, style and aedeagus; D, cercopod and anal valve, drawn one-fifth smaller than C; E, subgenital plate.

Type.—Nelson, 22.x.1923 (*E. Gourlay*).

Allotype.—Nelson, 8.xii.1921.

Paratypes, ♂, ♀, with allotype.—♂, 2 ♀, Upper Maitai Valley, 20.xii.1932. ♀, No date or locality given.

Tonnoir, in his manuscript notes, stated that he wished to dedicate this species to Mr. E. Gourlay, of the Cawthron Institute, Nelson, and suggested the name given above.

Pericoma spiralifera sp. n.

♂♀. Wing length 2·4 mm.

♂. Eye bridges separated by the width of one facet; antennae slightly longer than wing width; basal flagellar segment almost three times as long as wide (fig. 13A); terminal one ovoid with an apiculus longer than the basal bulb (fig. 13B). Palpal formula 2 : 4 : 5 : 8.

Thorax covered with a golden vestiture; wing vestiture and venation exactly as in *P. bifalcata*.

Hypopygium; 9th sternite of characteristic shape (fig. 13C); coxite with a well developed infrabasal process; style almost straight, curved at tip; aedeagus composed of four pieces; consisting of a long spiraliform, pointed element, and a shorter element bent through a right angle, both placed medially; a pointed element broadened basally placed on one side of these, and an irregular triangular element with a lateral tooth and a distal bluntly pointed projection, on the other; cercopod evenly tapered with a single retinaculum, anal valve triangular, almost half length of cercopods (fig. 13D).

♀. As in male; subgenital plate with triangular, slightly convergent lobes (fig. 13E).

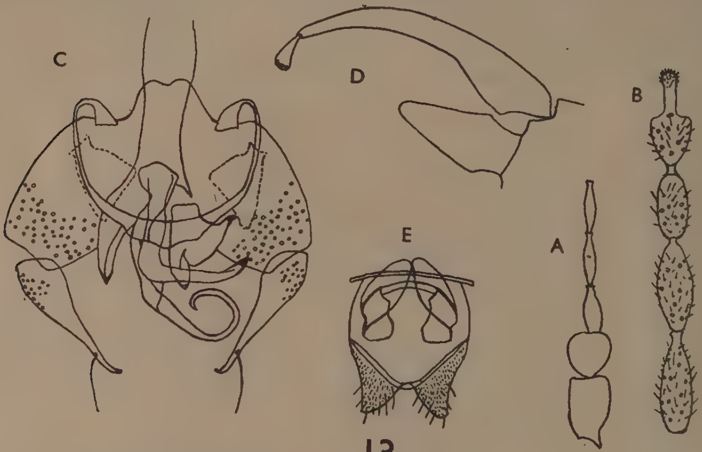

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FIG. 13.—*Pericoma spiralifera* sp. n. A, Base of, and B, tip of, antenna; C, coxite, style and aedeagus (some details of aedeagus added from a paratype); D, cercopod and anal valve, drawn one-fifth smaller than C; E, subgenital plate.

Type.—Reefton, 13.i.1922.

Allotype.—Otira, 7.ii.1922.

Paratype, ♂ with type.—♂, 2 ♀, Gourland Downes, 7.ii.1922 (*A. Philpott*).

I have adopted Tonnoir's suggested manuscript name for this species.

The two following species, *Pericoma serratipennis* and *P. furcata*, resemble each other and differ from the previous four species, in having the wing vestiture infuscated on the distal half of the wing. The body vestiture, however, is predominantly golden and they are probably more closely related to the previous four species than to the others described in this paper.

Pericoma serratipenis sp. n.

A pale golden-brown species with the wings infuscated in the distal portion, and an extensive white patch in the apical fringe.

♂♀. Wing length 2·5 mm.

♂. Eye bridges separated by the width of three facets; antennae as long as width of wing; basal flagellar segments (fig. 14A) not more than three times as long as wide, diminishing gradually so that preapical one is not more than one and one-half times as long as wide (fig. 14B); apical one subspherical with a club-shaped apiculus a little longer than basal bulb. Palpi unusually long and thin, two-thirds length of antennae; palpal formulae 7 : 14 : 18 : 25.

Thorax with whitish covering; wing (fig. 14C) with both forks before middle and distinctly before tip of Cu; posterior fork a little past anterior fork; origin of stem of anterior fork at apex of first basal cell; two basal cells equal; vestiture golden-brown, gradually darkening, infuscated on distal third; fringe whitish-yellow from R_2 to M_2. Legs with integument rather pale; the tarsi evenly covered with whitish-yellow scales; hairs of abdomen more yellowish than thorax.

Hypopygium; 9th sternite strap-like; coxite (fig. 14D) a little longer than broad, style rather long with a curved tapering tip; aedeagus complex, consisting of a long curved dorsal element terminating in a broad blade armed with minute spinules; a short stout element bluntly hooked at the tip, and a third element terminating in a swollen head with a lateral hook; cercopod long with a single short retinaculum; anal valve (fig. 14E) rounded, almost half length of cercopod.

♀. Similar to male, but hairs of head and thorax more yellowish, wing less infuscated; antennal joints more slender; subgenital plate as in fig. 14F.

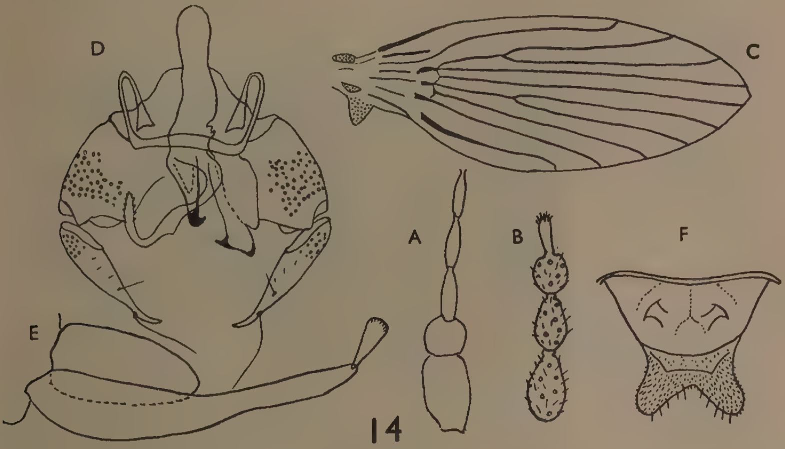

FIG. 14.—*Pericoma serratipenis* sp. n. A, Base of, and B, tip of, antenna; C, venation; D, coxite, style and aedeagus; E, cercopod, and anal valve; F, subgenital plate.

Type.—Dun Mountain, 5–7.i.1922.

Allotype.—Te Aroha, 1.iii.1923.

Paratypes.—4 ♂, 3 ♀, Upper Maitai Valley, 20.xii.1932. ♀, Wellington, 1.xii.1921.

Other specimens.—15 ♂, with paratypes. 2 ♂, Weltons Bush, 2.xii.1921. 2 ♂, Khandallah, 30.xi.1921. 5 ♂, Wellington, 1.xii.1921. ♀ Days Bay,, 29.xi.1921. ♀, Nelson, 4.iii.1922. ♂, ♀, Nelson 15.xii.1921. 2 ♂, ♀, Aniseed Valley, 1–4.xii.1923. 2 ♂, 3 ♀, Dun Mountain, 15.iii.1921. 6 ♂, 4 ♀, Dun Mountain, 2.i.1933. 2 ♀, Maitai Valley, 16–17.iii.1922. (*A. Philpott*).

Pericoma furcata sp. n.

A golden yellow species resembling *P. serratipennis* in the possession of a dark fascia on the wing, but without the apical white space in the fringe.

♂♀. Wing length 2·3 mm.

♂. Eye bridges separated by a distance of two facets; antennae a little longer than width of wing; basal flagellar segments (fig. 15A) a little more than twice as long as broad; diminishing gradually so that preapical one is just twice as long as broad; apical one with an apiculus longer than the basal bulb (fig. 15B).

Thorax with whitish-golden covering; wing with the two forks almost at the same level, the posterior one being slightly nearer the apex and about at the middle of Cu (fig. 15C); basal cells equal; vestiture golden-yellow, with a narrow transverse dark brown fascia extending from R_1 and broadening posteriorly so that it fills in the fringe from M_3 to just beyond M_4; also, a less well marked fascia above the basal cells; posterior fringe from tip of Cu to base, pale brown in colour. Legs uniformly golden yellow.

Hypopygium; 9th sternite (fig. 15D), strap-like with a characteristically indented anterior margin; coxite with a narrow infrabasal process, style as in related species; aedeagus complex, composed of three pieces; a flat, curved process forked at the tip lying medially, a simple blunt finger-like process on one side, a more plate-like process rounded apically but broader proximally, on the other; cercopod with a single retinaculum (fig. 15E); anal valve triangular, half as long as cercopod.

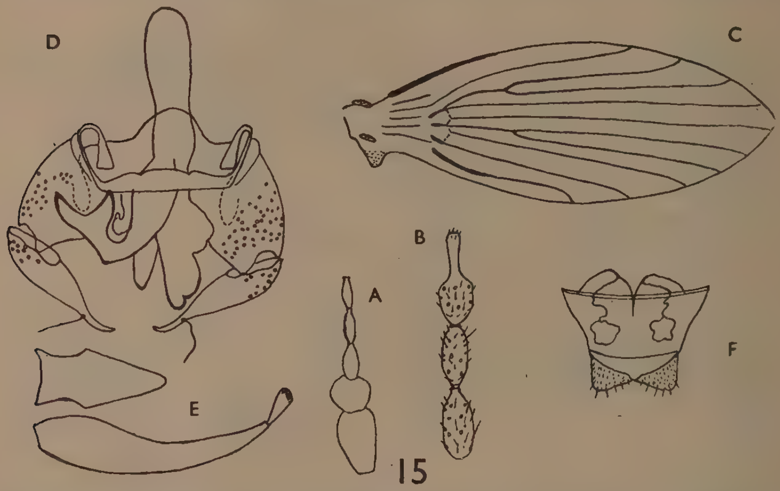

FIG. 15.—*Pericoma furcata* sp. n. A, Base of, and B, tip of, antenna; C, venation; D, coxite, style and aedeagus; E, cercopod and anal valve, drawn one-fifth smaller than D; F, subgenital plate.

♀. Similar to male; subgenital plate as in fig. 15F.

Type.—Aniseed Valley, 1–4. xii. 1923.

Allotype.—4 ♂, 4 ♀ paratypes, Upper Maitai Valley, 20. xii. 1932.

Other specimens.—10 ♂, with allotype. 3 ♂, 3 ♀, Khandallah, 30. xi. 1921. ♂, 4 ♀, Nelson, 15. xii. 1921; 2 ♀, 8. xii. 1921. ♂, ♀, Weltons Bush, 2. xii. 1921. 3 ♂, 2 ♀, Aniseed Valley, 1–4. xii. 1923. 2 ♀, Days Bay, 22. xi. 1921. ♀, Kaikoura, 22. ii. 1922.

Genus *Brunettia* Eaton.

Brunettia novae-zealandica sp. n.

A uniformly brownish-black species with nine white spots on the wing margin and some white hairs on the base and middle of the wing disc.

♂♀. Wing 2·5 mm. long by 1·3 mm. wide.

♂. Eye bridges narrow and touching; antennae 15-segmented, half as long again as width of wing, first segment twice as long as broad, second spherical, those of flagellum with asymmetrical basal bulbs and narrow parallel-sided necks which get proportionately longer towards tip, apical segment smaller than rest with a conical apiculus (fig. 16A); large curved ascoids present on segments 3–15 (fig. 16B); a small sensory cone above the base of each ascoid; verticils of flagellum rather close. Palpal formula 1 : 3 : 5 : 5.

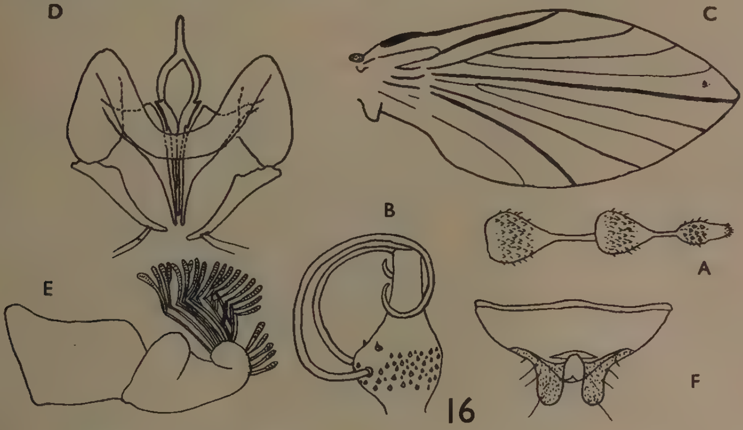

Fig. 16.—*Brunettia novae-zealandica* sp. n.—A, Tip of antenna; B, fifth antennal segment; C, venation; D, coxite, style and aedeagus; E, cercopod; F, subgenital plate.

Thorax without organs of erotic display; wing venation typical of the genus (fig. 16C), with all veins very straight and radiating from basal cells which are equal in length; two forks almost on same level and very near wing base; Rs pectinate, R_1, R_5 and M_4 very thick. Wing vestiture with brown hairs on whole surface except basal two-fifths of under-surface, where they are replaced by scales; wing fringe uniformly brown with a paler reflection; four white spots on anterior and four on posterior wing margin; a smaller spot present at wing tip, only seen in perfect specimens; a few erect white hairs in the middle and at the base of the wing disc; a long curved tuft of blackish-brown hairs on the alula and at base of costa. Legs brown, front tibiae with distal half white, mid and hind tibiae with only apices white, distal half of metatarsi and whole of next tarsal joint white.

Hypopygium; 9th sternite (fig. 16D), arcuate, with two projections lying parallel with, and enveloping, aedeagus; coxite longer than broad, style blunt apically with two pre-apical setae; aedeagus simple and symmetrical consisting of two pieces; cercopod very short and stumpy, with five or so short retinaculae proximally, and twenty-five or so more distally (fig. 16E).

♀. Similar to male, but eye bridges scarcely touching; antennae shorter with smaller ascoids, tuft on alula and base of costa less developed; scaley area on ventral wing surface less extensive; second tarsal joint less extensively white; subgenital plate as in fig. 16F

Type.—Nelson, 20.iv.1922.

Allotype.—Upper Maitai Valley, 20.xii.1932.

Paratypes.—♂, Nelson, 27.x.?. ♂, Lake Rotorua, 11.ii.? (*A. Philpot Philpott*). ♂, Dun Mountain, 2.i.1933. ♀, Weltons Bush, 2.xii.1921. ♀, Aniseed Valley, 1–4.xii.1923.

Genus *Psychoda* Latreille.

When the species of New Zealand Psychodidae are better known it will probably be found that those of the genus *Psychoda* out-number those of all the other genera. Peculiar difficulty attaches to a study of the New Zealand representatives of this genus, however, a difficulty which is reflected in the fact that only eleven species are described in this paper. Species of *Psychoda* are largely distinguished on characters of the genitalia, though in the European representatives of the genus, other characters, mainly the antenna tip and the wing venation, are important. Such characters are useful in linking the two sexes of a species together, and it is these non-sexual characters which are so often lacking in the New Zealand species. There exists a large number of species in which the antennae terminate identically, with three small, distinctly separated joints, whilst the wing venations are too much alike to be of use. No certain means exists of linking males with females, and the only solution to the difficulty is the chance taking of pairs *in copula*. It is for this reason that I have described only eleven species from the Tonnoir collection, whilst leaving thirteen species of males and twenty-two of females undescribed. I am reluctant to describe the sexes separately, whilst opportunities for further collecting exist, and the only three cases where I have described males without their corresponding females, is where there happens to be a reasonably good holding of male specimens and some non-sexual features which will probably be present in the female when it is found. It is, of course, easy to link the sexes in species which have some pattern on the wing, or legs, and that five out of the eleven species described have this feature must not be taken to mean that such coloured species are necessarily very common in the New Zealand fauna.

Psychoda spatulata sp. n.

A whitish-yellow species with a transverse blackish zigzag band across the wing. Extremely common everywhere.

♂♀. Wing length 2 mm.

♂. Eye bridges separated by width of one facet; head and base of antenna covered with a brownish vestiture; antenna 15-segmented, almost twice as long as width of wing; 1st segment almost twice as long as wide; basal flagellar segments with neck equal to bulb, neck distinctly longer in more distal segments; 13th segment with a well developed sensory cone on one side (fig. 17A), 14th very small and naked apart from a sensory cone, 15th ovoid; ascoids of the usual Y type.

Wing with anterior fork passed posterior and well before tip of Cu; a transverse zigzag band of dark hairs starting on fringe past the middle of R_1, crossing the anterior fork, reaching its most distal point on R_5, its most proximal on M_4, and terminating in the posterior fringe behind tip of Cu; erect hairs absent on R_5, M_4 and distal half of M_2; present on other veins right to the tip.

Hypopygium; coxite short (fig. 17B), and very swollen laterally, style bent in two places with a spatulate tip; a long curved seta half-way along the outer side and numerous small setae scattered over the surface; aedeagus simple and pointed; cercopod swollen at base (fig. 17C).

♀. Similar to male; subgenital plate (fig. 17D) with two widely divergent lobes constricted at the base; each lobe with a keel; genital digit ("internal sensory organ" of Tonnoir) cylindrical.

As none of the male specimens of the species in the Tonnoir collection shows the male genitalia in an uncontorted condition, I have used a specimen caught by myself in Dunedin as the type.

Type.—Museum Reserve, Dunedin, 20.viii.1949 (*G. H. Satchell*). (Type in Tonnoir collection.)

Allotype.—Nelson, ?.vii.1929.

Paratypes.—2 ♂, 2 ♀, with allotype. ♂, Days Bay, 29.xi.1921. ♂, Khandallah, 30.xi.1921. ♀, Waiho, 19.i.1922. ♀, Upper Maitai Valley, 20.xii. 1932.

Other specimens.—6 ♂, 3 ♀, with allotype. 2 ♂, Days Bay, 29.xi.1921. 3 ♂, 1 ♀, Khandallah, 30.xi.1921. ♂, Nelson, 14.xii.1921.

In the Canterbury Museum collections is a single ♀ specimen from Aniseed Valley, ?.iii.1922. In the British Museum collections are 4 ♂, 4 ♀, Ohakune, 1–9.iv.1923, collected by T. R. Harris, and one ♂, Dunedin, 16.iv.1923, colected by C. L. Edwards.

In his manuscript notes Tonnoir mentions that he has collected this species from Camberwell, Victoria, and Burrie, Tasmania, Australia.

This species is very closely related to the European species, *Ps. surcoufi* Tonnoir, and the South American *Ps. subimmaculata* Tonnoir. It is particularly closely related to the former, differing only in the genitalia. The larvae of *Ps. spatulata*, which I have reared on rotting potatoes, appear to be identical with those of *Ps. surcoufi* (Satchell, 1947). Tonnoir (1929), in describing the South American species, remarks how similar it is to an undescribed New Zealand species "which may be *Ps. conspicillata* Hutt." He had not, at that time, verified just which of the New Zealand species Hutton's (1881) description referred to, and as *Ps. spatulata* is by far the most common species in New Zealand, supposed that the description might refer to it. Tillyard (1926) followed Tonnoir in suggesting that the common New Zealand species may be *Ps. conspicillata* Hutton. When Tonnoir subsequently found some of Hutton's paratypes in the collections of the Canterbury Museum, they proved to be *P. alternata* Say, and *P. conspicillata* Hutton was added to the list of synonyms of that species (Tonnoir, 1934).

Psychoda zonata sp. n.

A yellowish-white species with brown wings banded with white.

♂♀. Wing length 2 mm.

♂ Eyes almost touching; head covering fuscous with white hairs on vertex; antennae 16-segmented, slightly longer than width of wing, base fuscous, remainder yellowish; basal flagellar segments with neck equal to basal bulb, but longer than bulb in more distal segments; the 13th with a much reduced neck, 14th and 15th only half diameter of 13th, wider than long and well separated; the 15th with a small sensory cone, 16th ovoid and smaller still; ascoids with long faintly annulated arms (fig. 17E).

Thorax whitish-yellow with a black tuft between wing bases; venations with anterior fork in middle of wing, posterior fork nearer base; wing vestiture brown with white hairs near the base and in two transverse fasciae, the proximal one extending from just before to just beyond radial fork, the distal one at level of tip of R_2 and extending almost to wing apex; white fasciae extending into both fringes; darker brown tufts located on R_4 and M_1 in darker area between the two white fasciae, and on the distal margin of the basal brown area, that on M_1 being the most distally placed; fringe white in four places, above and below the proximal and distal white fasciae. Legs fuscous with paler apical rings and scattered paler hairs on tarsi; tibiae darker brown subapiclly.

Abdomen with dark vestiture except for white tufts at base of genitalia.

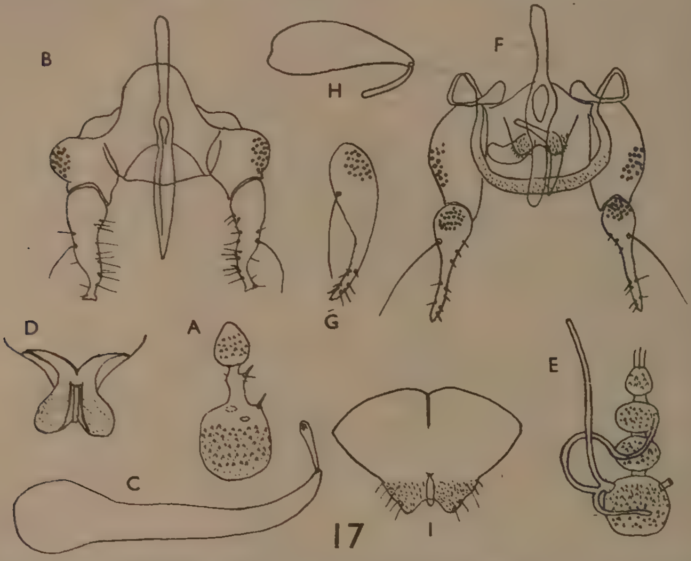

Fig. 17.—A–D, *Psychoda spatulata* sp. n.; E–I, *Psychoda zonata* sp. n. A, E, antenna tips; B, F, coxites, styles and aedeagus; G, style, from a paratype; C, H, cercopods; D, I, subgenital plates.

Hypopygium; 9th sternite narrow; coxite (fig. 17F) rather long, style curved and swollen in basal half (fig. 17G), with a large sub-basal seta; aedeagus asymmetrical and formed of two pieces, a straight median one rounded at the tip and a lateral pointed one lying alongside and crossing it basally; paired setose lobes basally; cercopod (fig. 17H) short, scarcely longer than 9th tergite; single retinaculum one-third length of cercopod.

♀. Similar to male; covering of legs and abdomen all whitish; subgenital plate as in fig. 17I.

Type.—Christchurch, 5.xi.1925.

Allotype.—Kaikoura, 22.ii.1922.

Paratypes.—♂♂. Dun Moutain, 1.x.1922 (*A. Philpott*); Maitai Valley, 17.iii.1922; Nelson, 20.iv.1922; Days Bay, 29.xi.1921; ♀♀, Dun Mountain, 5–7.i.1922 (2 specimens); Christchurch, 5.xi.1925; Days Bay, 29.xi.1921.

Other specimens.—♂, Christchurch, 18.ii.1922. 2 ♂, Upper Maitai Valley, 20.xii.1932 and 2.i.1933. ♂, Wellington, 1.xii.1921; 3 ♀, Nelson, 8.iv.1922, 20.iv.1922 and 9.x.1923. 2 ♀, Upper Maitai Valley, 20.xii.1932 and 17.iii.1922. ♀, Waiho, 30.i.1922. 2 ♀, Khandallah, 30.xi.1921. ♀, Otira, 9.ii.1922. ♀, Kaikoura, 22.ii.1922. ♀, Dun Mountain, 5–7.i.1922. 2 ♀, Days Bay, 29.xi.1921.

In the collections of the Canterbury Museum, Christchurch, are the following specimens: 1, genitalia missing, but probably a ♂, Khandallah, 30.xi.1921; ♂♀, Deans Bush, 8.i.1925.

In the collections of the British Museum are the following specimens: 1, genitalia missing, and 1 ♂, Ohakune, 1–9.iv.1923; ♂♀, Ohakune, v–vii.1923, all four collected by T. R. Harris.

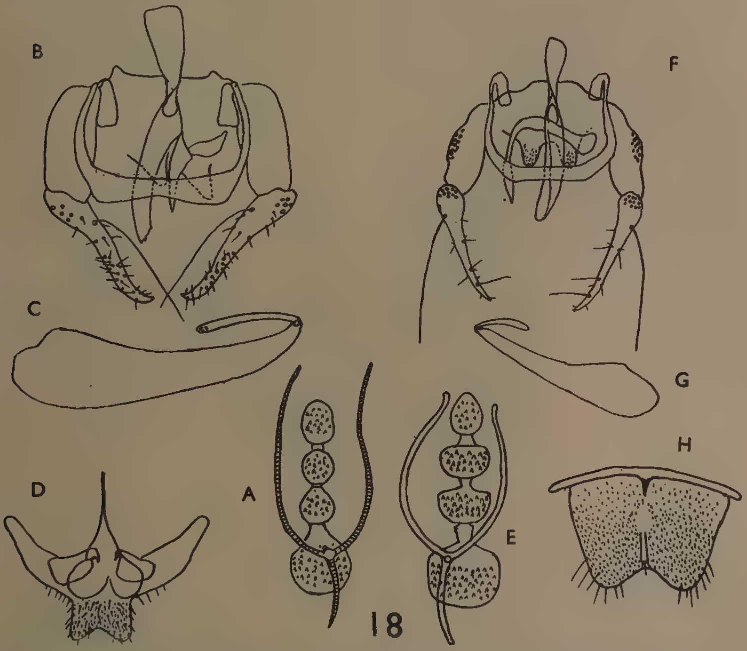

FIG. 18.—A–D, *Psychoda setistyla* sp. n.; E–H, *Psychoda novae-zealandica* sp. n. A, E, Antenna tips; B, F, coxites, styles and aedeagus; C, G, cercopods, one-fifth smaller than B and F; D, H, subgenital plates.

Psychoda setistyla sp. n.

A dark brown species with white spaces in the posterior wing fringe.

♂♀. Wing length 2·3 mm.

♂. Eye bridges almost touching; antennae 16-segmented, only as long as width of wing; flagellar segments with neck longer than bulb, which is slightly asymmetrical; 13th with a short neck; 14th, 15th and 16th subspherical, only half diameter of 13th, distinctly separated (fig. 18A); ascoids with long branches, which are strongly annulated.

Vestiture of thorax composed of hairs which are white basally, but dark brown at the tips; wing rather broad, anterior fork past posterior, M_3 bent upwards near the tip; wing vestiture brown, with two irregular rows of whitish spots; the more proximal one commencing anteriorly above the radial fork, and the more distal at the tip of R_2; the proximal row consisting of erect hairs on R_1, the radial fork, R_4, M_1, M_3 and Cu and of reclined hairs on R_5, M_2 and M_4; the distal of erect hairs on R_3, R_4, M_1 and M_3 and reclined hairs on R_5, M_2 and M_4; in both rows tufts of reclined hairs situated more distally than erect tufts; fringe with small white space at wing apex, a broader one extending from just above to just below tip of M_3, and a third extending proximally from tip of Cu for a distance equal to one-quarter of that vein. Legs dark brown, apical whitish rings on tibiae; tarsi whitish except at tip, but colour varying with angle of view.

Abdomen with dark brown vestiture.

Hypopygium; 9th sternite strap-like, narrow in centre (fig. 18B); coxite elongate and free from usual lateral tuft of long hairs; style gently curved with very numerous small setae distally, and one long seta inserted immediately beyond the swollen basal portion; aedeagus asymmetrical, consisting of a long, gently curved, median piece, a smaller pointed piece beside it, and two bluntly triangular pieces below; cercopod nearly twice as long as 9th tergite; single retinaculum one-third length of cercopod (fig. 18C).

♀. Similar to male, but ascoids relatively smaller; subgenital plate as in fig. 18D.

Type.—Aniseed Valley, 1–4.xii.1923.

Allotype.—Days Bay, 29.xi.1921.

Paratypes.—♂♂, one with type, one with allotype. Also Nihotapu, 25.ii.1923; Otira, 10.ii.1922. ♀♀, Weltons Bush, 2.xii.1921; Khandallah, 30.xi.1921; Kaitouna, 19.ii.1922.

Other specimens.—4 ♀, Khandallah, 30.xi.1921. 3 ♀, Kaitouna, 19.ii.1922. 2 ♀, Kaikoura, 22.ii.1922. ♀, Days Bay, 29.xi.1921. ♀, Weltons Bush, 2.xii.1921.

In the collections of the Canterbury Museum, Christchurch, are the following specimens: 2 ♂, ♀, Akaroa, 9–10.xii.1924. ♀, Lake Moana, 16–21.xii.1925. ♀, Deans Bush, 20.xii.1927 (*S. Lindsay*). ♀, Kaitouna, 19.ii.1922.

Psychoda novae-zealandicae sp. n.

A uniformly whitish fuscous species, but its colour changes with the position of the light, and it may appear darker in certain positions.

♂♀. Wing length 1·7 mm.

♂. Eye bridges just separated; antennae 16-segmented, twice as long as width of wing, basal flagellar segments amphora-shaped, others with bulb the usual subspherical shape, and neck one and one-half times as long as bulb; neck gradually shortening in more distal segments, but still longer than bulb in 12th segment; 13th with a distinct neck (fig. 18E), 14th and 15th wider than long, a little more than half the diameter of 13, distinctly separated; 16th oval, a little narrower still; ascoids with moderately long anterior arms.

Wing rather broad, stem of R_{2+3} joining R_4 at a distance from apex of first basal cell equal to twice width of that cell; levels of anterior and posterior forks separated by a distance equal to one-eighth of wing length.

Hypopygium; 9th sternite strap-like (fig. 18F); coxites long and slightly bulging laterally; style long and only slightly curved at tip, and slightly swollen basally; a long seta inserted just beyond the swollen basal region, and a second one near the apex; aedeagus consisting of a bluntly pointed central piece, and a curved pointed piece on one side; two small pilose lobes separated by a median indentation, below aedeagus; cercopod of moderate length (fig. 18G).

♀. Similar to male; subgenital plate with a cylindrical genital digit, as in fig. 18H.

Type, allotype, 4 ♂, 4 ♀, *paratypes*, Dun Mountain, 2.i.1933.

Other specimens.—11 ♂, 1 ♀, with type. 3 ♂, 2 ♀, Waiho, 30.i.1922. 2 ♂, 3 ♀, Nelson, 15.xii.1921. 2 ♂, Nelson, 20.iv.1922. ♂♀, Kaikoura, 22.ii.1922. ♂, Mt. Arthur, 25.xii.1921.

I have adopted the name suggested by Tonnoir in his manuscript notes for this species.

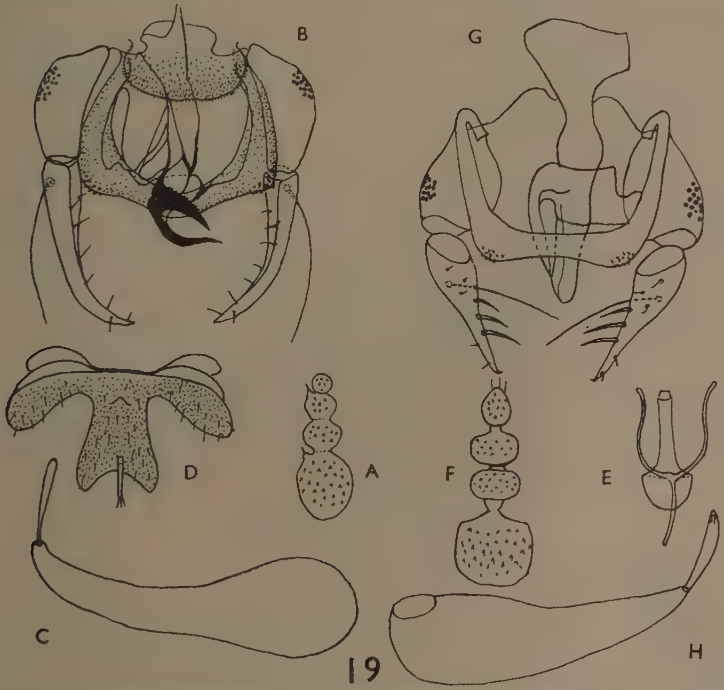

FIG. 19.—A–D, *Psychoda harrisi* sp. n.; E–H, *Psychoda triaciculata* sp. n. A, F, Antenna tips, drawn from paratype ♂♂; E, basal flagellar joints; B, G, coxites, styles and aedeagus; C, H, cercopods; D, subgenital plate.

Psychoda harrisi sp. n.

A uniformly light brown species with the last four antennal joints not distinctly separated.

♂♀. Wing length 1·7 mm.

♂. Eye bridges touching or almost so; antennae almost twice as long as width of wing; the last four joints (fig. 18A) not distinctly separated; the 13th spherical, 14th and 15th only half diameter of 13th, and the 16th smaller still; the 13th and 15th provided each with a small process bearing a sensory cone; ascoids of the usual type.

Wing with origin of R_{2+3} at apex of first basal cell, which is a little longer than the second; anterior fork well past posterior, which is midway between level of anterior fork and second basal cell.

Hypopygium; 8th segment bearing a dorsal projecting lamella (fig. 19B), 9th sternite of characteristic shape, minutely setulose on outer margins; coxites short, rounded laterally, style falcate, triangular in section, with a large seta near the base; aedeagus complex, largely membranous in basal portion, terminating in two pointed curved processes, one of which is minutely serrate on its anterior margin; cercopod (fig. 19C) short, swollen basally, with a moderately long retinaculum.

♀. Similar to male, but eye bridges separated by a distance of two facets; subgenital plate elongate, with divergent sides; genital digit long, cylindrical, terminating in three setules; a prominent hairy plate on each side of subgenital plate (fig. 19D).

Type.—Nelson, 14.xii.1921.

Allotype.—Ohakune, 4.v.1927 (*T. R. Harris*).

Paratypes.—♂♂, one with type, one with allotype. Kaikoura, 23.ii.1922 (2 specimens). ♀♀, Nelson, 18.iv.1922. Nihotapu, 25.ii.1923 (2). Kaikoura, 22.ii.1922.

Other specimens.—8 ♂, 11 ♀, Ohakune, 4.v.1927 (*T. R. Harris*). 2 ♂, Nelson, 22.iv.1922 and 23.v.1922. 3 ♂, 3 ♀, no name or locality. 4 ♂, Nihotapu, 24–25.ii.1923. 3 ♀, Kaikoura, 23.ii.1922. 5 ♀, Nelson, 14.xii.1921, 20.iv.1922, 22.iv.1922, 20.viii.1922 and 8.xi.1923. Another ♀, same locality (*A. Philpott*), 7.vii.1921. ♀, Aniseed Valley, ?.iii.1922. All this material is in the Tonnoir collection. In addition, fifteen specimens of this species, 5 ♂, 10 ♀, are in the collections of the British Museum, and bear the label "Ohakune, 1–9.iv.1923, collected T. R. Harris."

In his manuscript notes Tonnoir mentions that this species is also found in Australia and refers to specimens, not in the collections, from Adelaide and Eastwood (N.S.W.), and Glenora, Tasmania. I have named the species after Mr. T. R. Harris, who has collected many specimens of PSYCHODIDAE from Ohakune, including the allotype of this species.

Psychoda triaciculata sp. n.

A uniformly fuscous-greyish species.

♂. Wing length 2 mm.

♂. Eyes touching; antennae 16-jointed, 1·7 times as long as width of wing; basal flagellar segment amphora-shaped, remainder usual shape (fig. 19E), neck more than one and one-half times length of bulb; last three segments diminutive (fig. 19F), well separated, as in *Ps. novae-zealandicae*, ascoids very long, with posterior branch reaching to next bulb.

Wing with anterior fork in middle, not much past level of posterior fork; distance between two fork levels equal to one-eighth of wing length.

Hypopygium; 9th sternite (fig. 19G) rather deep, minutely setulose on outer margins; coxite longer than wide, style short, straight, and tapering, with one very long seta near the base and a row of three short thick, needle-like setae in the centre of the inner face; aedeagus with a straight, bluntly pointed central piece, and a curved pointed piece on one side; paired setose lobes are not present ventrally, cercopod long, evenly tapered (fig. 19H).

♀. Unknown.

Type.—Kaitouna, 19.ii.1922.

Paratypes. 2 ♂, Otira 9–10.ii.1922. ♂, Waiho, 19.i.1922. ♂, Upper Maitai Valley, 20.xii.1932. ♂, Weltons Bush, 20.xii.1921.

Psychoda lloydi sp. n.

A uniformly pale fuscous species.

♂. Wing length 1·7 mm.

♂. Eye bridges just separated; antennae 16-segmented, twice as long as width of wing; basal flagellar segment amphora-shaped, slightly asymmetrical, neck a little longer than bulb (fig. 20A), remaining segments with bulb subspherical and neck half as long again as bulb; last three diminutive and distinctly separated (fig. 20B); ascoids with long anterior branches.

Thorax and legs with a light fuscous vestiture on a pale brown integument; wing with anterior fork in centre; distance between fork levels equal to one-seventh of wing length.

Hypopygium; 9th sternite moderately deep (fig. 20C); coxites longer than broad; style short, curved and evenly tapering, with one long seta inserted near the base; aedeagus with a median blunt process and a lateral curved pointed process; paired pilose lobes present ventrally; cercopod (fig. 20D) short, only a little longer than 9th tergite; retinaculum nearly half as long as cercopod.

♀. Unknown.

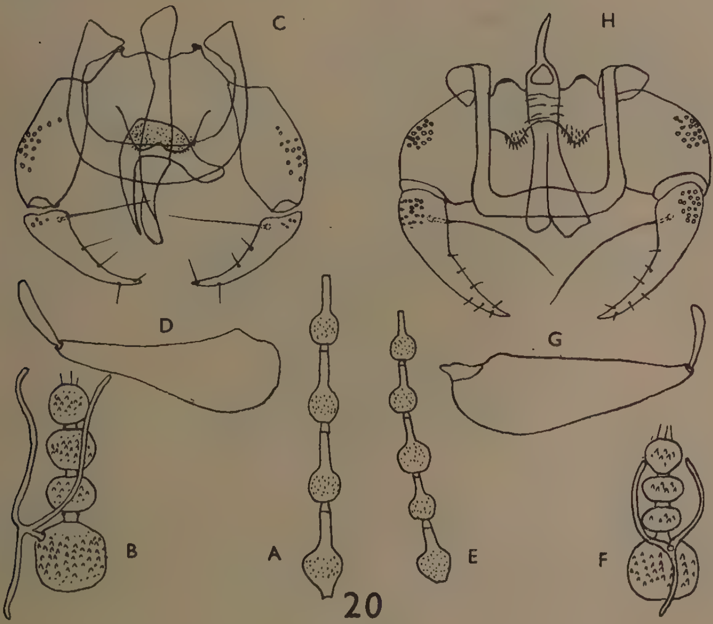

FIG. 20.—A–D, *Psychoda lloydi* sp. n.; E–H, *Psychoda squamullata* sp. n. A, E, Basal flagellar segments; B, F, antenna tips, drawn from paratypes; C, H, coxites, styles and aedeagus; D, G, cercopods.

Type and 5 ♂ *paratypes.*—Mount Arthur, 25.xii.1921.

I am naming this species after Dr. Ll. Lloyd, my former chief, who first interested me in the family PSYCHODIDAE. This species and the previous one belong to a group of species all of which closely resemble *Ps. novae-zealandicae.* Three others, represented each by one or two specimens, are in the Tonnoir collection. Not only do they resemble each other in antennal and wing characters, but the aedeagus in all consists of a central bluntly-ended piece, and a lateral pointed piece beside it. They differ mainly in the chaetotaxy of the style, and the presence or absence of paired pilose lobes below the aedeagus.

Psychoda squamulata sp. n.

A fuscous-grey species with the male thorax covered with squamuliferous hairs.

♂. Wing length 1·7 mm.

♂. Head with a tuft of fuscous-greyish scales on vertex ; antennae half as long again as width of wing ; basal flagellar segment amphora-shaped, the neck equal to the bulb (fig. 20E), the remainder with the bulb more nearly spherical ; the last three diminutive (fig. 20F) and well separated ; ascoids with anterior arms scarcely longer than posterior arms.

Thorax with a dark brown integument covered with a vestiture of greyish squamuliferous hairs ; a tuft of such hairs on the pleura, below the wing base ; wing with pale fuscous vestiture (darker in some specimens), the colour changing with the position of the light ; anterior fork slightly before middle of wing ; separated from level of posterior fork by a level equal to one-sixth of wing length.

Abdomen with a vestiture of fuscous-greyish hairs.

Hypopygium ; 9th sternite (fig. 20G) shaped like three sides of a rectangle ; coxite longer than broad, style angulated just before centre of inner margin ; a long seta inserted just before the base ; aedeagus with proximal end shaped like the tang of a chisel ; the distal end bifurcated into a rounded and a square-ended piece ; paired spiny lobes present below aedeagus ; cercopod short with retinaculum only one-quarter its length (fig. 20H).

♀. Unknown.

Type and 6 ♂ *paratypes.*—Wellington, 1.xii.1921.

Other specimens.—2 ♂, Khandallah, 30.xi.1921.

In the collections of the Canterbury Museum, Christchurch, is a single ♂, Okarahia, 5.ii.1925.

Psychoda inaequalis sp. n.

A dark brown species with paler wings characterized by lighter apical rings on the tibiae and first three tarsal joints.

♂♀. Wing length 1·8 mm.

♂. Eye bridges separated by width of one facet ; antennae 16-jointed, almost three times width of wing ; flagellum whitish to fuscous, white scales on scape ; basal flagellar segments amphora-shaped, with neck only slightly longer than bulb ; succeeding segments with bulb oval in outline, and neck distinctly longer (fig. 21A) ; 13th segment with a distinct neck, 14, 15 and 16 smaller, distinctly separated, with a small sensory cone on 15 ; ascoids with one arm longer than the other (fig. 21B).

Thorax with dark brown integument and a vestiture of long pale fuscous hairs ; a row of white squamuliferous hairs bordering anterior margin of thorax, another a little further back, and two longitudinal rows of such hairs crossing them at right angles. Wing with R_{2+3} arising on R_4 at a distance from first basal cell equal to width of that cell ; anterior fork well past middle of wing (fig. 21C), posterior fork near wing base ; distance between fork levels equal to one-quarter of wing length ; wing membrane infuscated over bases of radial veins ; vestiture of wing yellowish-white, darkening to brown at base. Legs brown with more or less distinct lighter apical rings on tibiae and first 3 tarsal joints.

Abdomen with brownish hair ; a patch of lighter fuscous scales ventrally, below genitalia.

Hypopygium ; 9th sternite very narrow (fig. 21D) ; coxite only a little longer than broad ; style evenly tapered with a small preapical seta ; aedeagus complex, consisting of one blunt and three pointed processes ; cercopod very short ; single retinaculum more than half as long as cercopod (fig. 21E).

♀. Similar to male, except for white scales ventrally, behind subgenital plate, which is characteristically shaped (fig. 21F).

Type.—Purau Creek, 20.ii.1922.

Allotype.—Days Bay, 29.xi.1921.

Paratypes.—♂♂, Nelson, 4.iii.1922 (1) and 18.x.1923 (2). Kaitouna, 19.ii.1922. ♀♀, Ohakune, 4.v.1927 (*T. R. Harris*). Wellington, 1.xii.1921. Upper Maitai Valley, 20.xii.1932. Nelson, 15.xii.1921.

Other specimens.—♂, Days Bay, 29.xi.1921. ♀, Wellington, 1.xii.1921.

In the collections of the British Museum there is a single ♂, Ohakune, 1–9.iv.1923 (*T. R. Harris*).

In the collections of the Canterbury Museum, Christchurch, there are 5 ♂, 2 ♀, from Akaroa, 10.xii.1924.

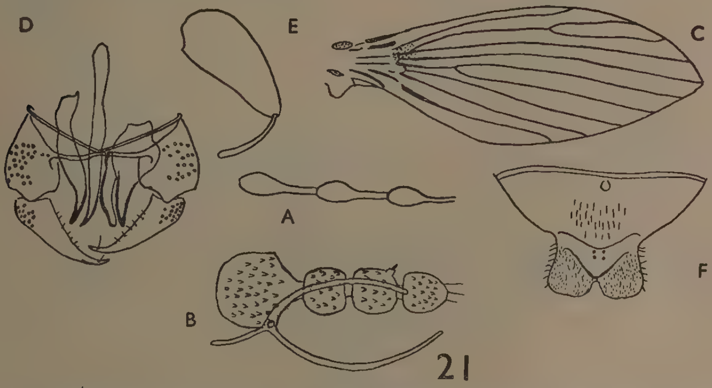

FIG. 21.—*Psychoda inaequalis* sp. n. A, Basal flagellar segments, and B, tip of antenna, drawn from allotype ; C, venation ; D, coxite, style and aedeagus ; E, cercopod ; F, subgenital plate.

Psychoda philpotti sp. n.

A very characteristic species with yellowish wings blackened at the base and blackish legs with white tarsi.

♂♀. Wing length 2·4 mm.

♂. Eye bridges separated by a distance of two facets ; antennae 16-segmented, twice as long as width of wing ; basal flagellar segment amphora-shaped, succeeding segments with more nearly spherical bulbs ; 13th with a short neck, 14th and 15th spherical, 16th oval ; ascoids with only one anterior arm, shaped as in fig. 22A ; flagellum white, base of antennae brownish.

Thorax and basal fifth of wing with a brownish-black vestiture, remainder of wing yellowish-white. Wing lanceolate (fig. 22B), anterior fork very little behind tip of R_1, posterior fork nearer to basal cell than to anterior fork ; wing membrane infuscated and veins thickened under area bearing blackish vestiture ; legs with brownish-black vestiture ; apex of tibiae and whole of tarsi white.

Abdomen with brownish-black vestiture.

Hypopygium ; 9th sternite very narrow ; coxite (fig. 22C) longer than broad ; style swollen basally, bent through almost a right angle (fig. 22D) and terminating in a short flat blade ; aedeagus composed of a central curved pointed piece with a second curved pointed piece beside it ; cercopod short and thick, with a short retinaculum (fig. 22E).

♀. Similar to male, but antenna relatively shorter ; subgenital plate as in fig. 22F.

Type, allotype, 5 ♂, 3 ♀, *paratypes.*—Mount Arthur, 24.xii.1921.

In his notes Tonnoir writes, "Dedicated to my friend, the late Alfred Philpott, who called my attention to this species while collecting in his company."

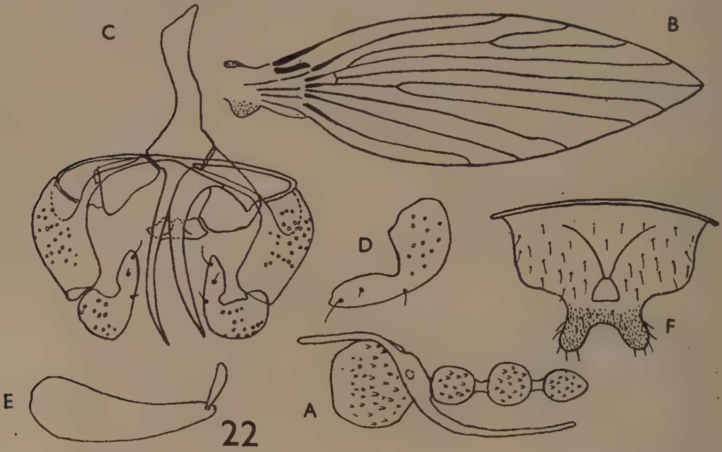

FIG. 22.—*Psychoda philpotti* sp. n. A, Tip of antenna; B, venation; C, coxite, style and aedeagus; D, style, enlarged, from a paratype; E, cercopod; F, subgenital plate. A and B drawn from allotype.

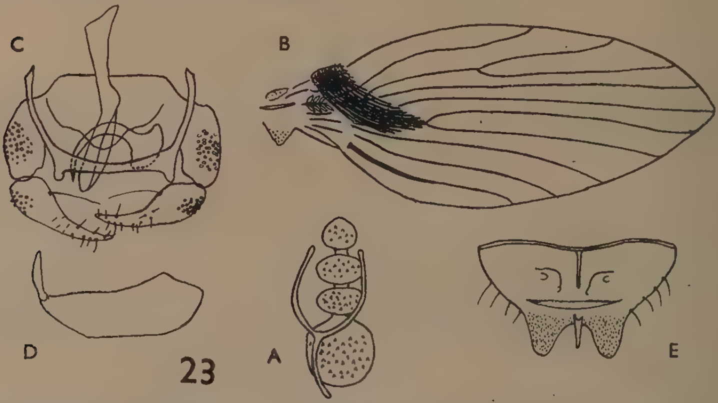

FIG. 23.—*Psychoda penicillata* sp. n. A, Tip of antenna; B, wing; C, coxite, style and aedeagus; D, cercopod; E, subgenital plate.

Psychoda penicillata sp. n.

An ochraceous winged species with dark abdomen, characterised by the long recurved tuft of hairs on the under surface of the male wing.

♂♀. Length of wing 1·7 mm.

♂. Eye bridges separated by width of one facet; antennae almost twice as long as width of wing; flagellar segments with neck slightly longer than bulb basally, distinctly so distally; the 13th with no trace of neck, 14th and 15th wider than long, a little more than half as wide as 13, 16th smaller still and subspherical; ascoids of the usual Y type.

Vestiture of wing and thorax uniformly ochraceous-brown ; wing with a long recurved tuft of scale-like hairs on underside, extending from base of costa to forking of M, arising on a small reflected flap at base of costa (fig. 23B) ; a much smaller cluster of short scales on base of R. Legs glossed with whitish hairs.

Abdomen covered with dense tufts of greyish squamuliferous hairs.

Hypopygium ; 9th sternite (fig. 23C) prolonged backwards at outer edges ; coxite short ; style short and rather bulbous at base, with a long seta near the base ; aedeagus consisting of a strong median element ending bluntly, and a curved hook-like element beside it ; cercopod short (fig. 23D), with a short retinaculum.

♀. Similar to male but lacking the long curved tuft and the basal scales ; abdominal hairs not squamuliferous ; subgenital plate as in fig. 23E.

Type.—Wellington, 1.xii.1921.

Allotype.—Waiho, 21.i.1922.

Paratypes.—♂♂, Nelson, 2.xii.1921 (1) and 30.x.1923 (2) ; Weltons Bush, 2.xii.1921. ♀♀, Christchurch, 17.ii.1922 ; Wellington, 1.xii.1921 ; Nelson, 3.xii.1921 (2).

Other specimens.—♂, Dun Mountain, 5–7.i.1922. ♂, Aniseed Valley, 21.iii.1922. ♂, Nelson, 30.xi.1923. 2 ♀, Purau Creek, 20.ii.1922.

In his manuscript notes Tonnoir refers to 2 ♂, ♀ specimens of this species sent by Dr. Ferguson, from Sydney, Australia, on 26.vi.1922, and to a ♂ and several ♀♀ from Camberwell, Victoria, sent by Mr. Deane, 17.xi.1922. These specimens are not in the collection.

In addition to the new species described in this paper, three cosmopolitan species of *Psychoda* also occur here. They are *Psychoda alternata* Say, *Psychoda severini* Tonnoir subsp. *parthenogenetica* Tonnoir and *Psychoda cinerea* Banks. *Ps. severini* is extremely common, and almost rivals *Ps. spatulata* in abundance at times. *Ps. alternata* is not commonly met with, perhaps because sewage purification works are almost unknown in New Zealand.

Very little can usefully be said about the relationships of the New Zealand PSYCHODIDAE because the Psychodid fauna of the surrounding countries is so poorly known. That of Australia is virtually undescribed, though, as mentioned in this paper, it appears that at least three species of *Psychoda* are common to the two countries. The PSYCHODIDAE of South America are very patchily described, the most important study being that of Tonnoir (1929) on a collection from Patagonia and South Chile. Tonnoir points out certain resemblances to the New Zealand fauna, noting the presence in both of the genera *Nemopalpus*, *Trichomyia* and *Sycorax*. Moreover, the species of *Pericoma* in both countries are peculiar in having a pectinate radial sector, with the stem of R_{2+3} arising from R_4 after the origin of R_5, and in having the cercopod armed with a single retinaculum. The genus *Brunettia*, however, has links with the Indo-Malayan fauna. As we clearly know only a fraction of the species in these countries, and almost nothing of the fauna of the Pacific islands, it would be premature to generalize further ; all that can be said is that the New Zealand Psychodid fauna has a greater resemblance to that of South America than to that of any other country so far described.

ACKNOWLEDGMENTS.

It is a pleasure to acknowledge my indebtedness to Dr. David Miller, of the Cawthron Institute, Nelson, for the loan of the Tonnoir collection of New

Zealand PSYCHODIDAE ; to Mr. Paul Freeman, of the British Museum, for the loan of specimens and for much helpful advice, and to Mr. R. R. Forster, of the Canterbury Museum, Christchurch, for the loan of specimens from the Hutton collection.

SUMMARY.

The loan of the Tonnoir collection of New Zealand PSYCHODIDAE and manuscript notes permits the following new species to be described :

Trichomyia fusca sp. n.
Sycorax cryptella sp. n.
S. impatiens sp. n.
S. dispar sp. n.
S. milleri sp. n.
Pericoma multimaculata sp. n.
P. triuncinata sp. n.
P. drepanata sp. n.
P. mauru sp. n.
P. lobisterna sp. n.
P. bifalcata sp. n.
P. gourlayi sp. n.
P. spiralifera sp. n.
P. serratipenis sp. n.
P. furcata sp. n.
Brunettia novae-zealandica sp. n.
Psychoda spatulata sp. n.
Ps. zonata sp. n.
Ps. setistyla sp. n.
Ps. novae-zealandica sp. n.
Ps. harrisi sp. n.
Ps. triaciculata sp. n.
Ps. lloydi sp. n.
Ps. squamulata sp.n.
Ps inaequalis sp. n.
Ps. philpotti sp. n.
Ps. penicillata sp. n.

The species *Pericoma funebris* Hutton is further described and the affinities of the New Zealand Psychodid fauna are discussed. It is concluded that it shows certain resemblances to that of South America, but that too little is known of the PSYCHODIDAE of nearby lands for any definite conclusions to be drawn.

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A REVISION OF THE GENUS *TENARIS* HÜBNER (LEPIDOPTERA: AMATHUSIIDAE).

By C. Joslin Brooks, F.R.I.C., F.R.E.S.

Manuscript received 26th October, 1948.
(Read 7th December, 1949.)

With 8 Plates, 1 Map and 1 Text-figure.

During the incorporation of recent accessions in the genus *Tenaris* from various sources, and the amalgamation of the Rothschild Collection from Tring with the General Collection in the British Museum (Nat. Hist.), I was impressed by the large number of species and subspecies in the genus and the extensive variation which occurred among them. From the material available, which I estimate at 6–7000 specimens, including many rare and little known forms in long series, and the majority of the types, it appeared to me that a more systematic examination than had hitherto been possible would give a better understanding of the relationship between the species. Although much had already been published, the few workers on the genus appear to have been handicapped by the lack of sufficient material.

For help in carrying out this work I wish to place on record my thanks to the Trustees of the Museum for the opportunity and facilities they have granted me, and to the Museum Staff and other workers who have so generously given me advice and assistance, namely Mr. N. D. Riley, Mr. A. G. Gabriel, the late Dr. A. S. Corbet, Brigadier W. H. Evans, and Mr. Goodson of the Zoological Museum, Tring.

I am indebted to Miss F. E. Gorniot for the beautiful drawings of the specialized scales *in situ*.

I have excluded *Morphotenaris* from this revision, considering that this monospecific genus is well separated from *Tenaris*, although closely allied.

A casual examination of the genus conveys the impression that a remarkable similarity exists in the marking of the majority of the species; this is especially the case among many of the females, and on the underside of both sexes, the difference in many cases only becoming obvious on close scrutiny. This was confirmed by the number of wrongly determined specimens which I found in the collections. In many cases the published description of the species is meagre and, without the type, determination almost impossible. Also, there are single specimens, some of which have been named, which are difficult to place; until series of these have been obtained, their position must remain obscure.

The wing pattern is simple and the colour range confined to yellow, shades of brown, to black and white, with varying shades of grey, blue occurring only in the eye spots or ocelli. These colours are restricted to broad bands and zones, varying in their extent, and cover the whole fore wing. Excluding the dark outline of the veins, which appear on some species, no lines occur.

The ocelli on the hind wing are very conspicuous and subject to wide variation in form and number; additional ocelli may occur in any species, or they may be absent, as will be more fully discussed in the detailed descriptions.

The extreme variability of many of the races and the sensitive response to environment, or varying conditions of the country, must be strongly emphasized. Certain species are directly separable into geographically localized light and dark forms. So far I have been unable to trace any seasonal variation. Varieties not only occur in what appears to be the dominant race, but these again break away into a series of varying forms, as though a fixed type was not yet established. This variation accounts for the large number of subspecies and forms that have received recognition. Yet in collections from new districts novelties are still of frequent occurrence, and it may be anticipated that many more will ultimately be described.

The range of habitat extends from sea level up to 6000 feet, but the genus more frequently occurs in low country, flying in shade. My only experience of taking these insects was in Amboina, where *Tenaris urania* is common, flying between the shady banks of streams at sea level.

Little is recorded of the early stages. Presumably the foodplant is a monocotyledon of the order PALMACEAE.

The larva and pupa of *T. phorcas uranus* Staudinger have been mentioned and figured by C. Ribbe (1895, *Deutsche ent. Zeit. Lep.* **8** : 113, t. 3, f. 10, 11). He found 40 larvae at Mania feeding on a species of palm and described them as sluggish creatures; after pupation only two imagines emerged. The illustration shows a larva of which the legs , clasps and underside are dark brown, above is a deep carmine stripe separated by a narrow brown line from a broad white stripe, subtended by a dark dorsal line, these stripes extending from the head over the length of the body, the whole being covered with fine white hairs. The head is black with two short horn-like extensions on both sides of the summit. The pupa is dark green, having a rather stout symmetrical body terminating abruptly, extended on the dorsal side.

A series of blown skins from the Fruhstorfer and Rothschild collections comprises *T. myops wahnesi* Heller (1), *T. dimona trita* Fruhstorfer (4), *T. artemis staudingeri* Honrath (5), and *T. gorgo gorgo* Kirsch (1). While the species differ from one another they agree in the type of marking, which is confined to a series of narrow light brown longitudinal lines on a pale brown skin. There is no indication of colour, other than shades of brown, which if present during life has now faded out. The form of the head is similar to that of *T. uranus*, also the body is covered with fine hairs, in this case pale brown.

I have avoided inserting in the text references to original descriptions, other than those published after 1933. They are extremely numerous, and their insertion would involve a large extension of space; those who are interested can find them by consulting H. Stichel's *Lepidopterorum Catalogus*, Fasc. 54, AMATHUSIINAE, or Wytsman's *Genera Insectorum*, Fasc. 36, AMATHUSIINAE.

Geographical Distribution.

I can add nothing to the already known range of the genus, which is shown on the accompanying map (p. 239). It will be noticed that only one species, *T. horsfieldii*, is found at the extreme western limit, on Palawan, Borneo and Java, while a few specimens have been taken on South Malaya and Sumatra. From the Philippines (excluding Palawan), Celebes, and the Lesser Sunda Islands, there is no record of any established species, so that these islands form a wide barrier line of separation from New Guinea and the Eastern Islands where the species are abundant. A few specimens of well-known species from the neighbouring islands have been taken on Celebes. These are doubtless wanderers, which though they reach this island are unable to establish themselves.

Tenaris is common and firmly established on the Moluccas. It is remarkable that it is absent from the barrier islands mentioned above, especially as the conditions must be similar throughout, and presumably the foodplant would occur there. I cannot offer any explanation.

It is significant that the nearly related genus *Faunis* extends to Celebes but not to New Guinea or the adjacent islands. There is no authentic record of more than one species, *T. phorcas*, occurring on the Bismarck and Solomon Islands.

Judging from the number of species and the fact that all the groups into which the genitalia are arranged, except *horsfieldii*, occur on New Guinea, it appears that this island is the centre from which the genus originated, and from which distribution has taken place, but, while the varying conditions over the whole island appear to be suitable to a number of species, others are local, or confined in their range. One sub-species is recorded from Australia. There is also a surprising absence from some of the adjacent islands, where one would anticipate their occurrence.

The Geographical Distribution and Attendant Variation.

It is well known that the climatic conditions of New Guinea vary considerably in the different sections of the island, especially the rainfall, but so few data are available that one is unable to make definite deductions as to the effect of this on the butterfly population—more extended knowledge of the ecological conditions is needed. However, these varying conditions appear to be the only explanation of the persistent alteration in colour and grades of marking, which are related to the various districts and followed by the different species as they occur there. The physical conformation, with high mountain ranges and enclosed valleys, and great rivers, adds considerably to the isolation of the races.

The area inhabited by *Tenaris* may be roughly divided into seven sections, in each of which, to a large extent, the species follow somewhat parallel modifications in colour and marking.

Areas.	Characteristic colour and marking.
1. The Moluccas, with Ceram and Buru	Strong colours, with prominent marking, not subject to extensive variation.
2. The western Peninsula of New Guinea and neighbouring islands, to somewhat west of the south of Geelvink Bay.	Dusky and dark forms, of which those from Mysol are often distinctively dark.
3. Jobi Island, and the country north of the Main Range, including Mandated Territory.	Light forms, in which the white is generally very pure, the markings more defined and often nearly black.
4. South of the Main Range to the north coast of the Gulf of Papua. The country in the south from the Eilanden River to the Fly River is sparsely represented, apparently much of this is low-lying jungle (perhaps not favoured by collectors.)	Yellow in the basal areas of the hind wing, with a warmer shade of brown.
5. The east coast of the Gulf of Papua over the terminal peninsula, British New Guinea.	White with dark to black markings; and the most melanotic forms.
6. The islands at the South-east of New Guinea.	White predominates, the markings reduced.
7. Malaysian Islands—Palawan, Borneo and Java—and Schouten Islands and the Solomon group. (Each of these has its characteristic species, but as they are so few they cannot be considered in relationship to divisions where a number of species occur).	Strong colours, very distinct forms. Schouten Islands are distinguished by two species, one of which is confined to those islands.

The most complete example of this variation is shown by *Tenaris catops*, *T. myops* and *T. artemis* and reviewed under those species. Also a table of the distribution of the species is appended (Table I).

TABLE I.—*Geographical Distribution of* Tenaris.

	Western Islands.					The Mainland of New Guinea.								Eastern Islands.				
	Malaysia.	N. Moluccas.	S. Moluccas.	Western Islands.	Aru.	Western Peninsular.	South of Snow Mts.	Schouten Is.	N. W., Geelvink to Humboldt Bay.	N. E., Mandated Territory.	West, British N. G.	South, and Port Moresby.	Milne Bay.	Bismark Is.	Solomon Is.	Trobriand Is.	D'Entrecasteaux Is.	Louisiade Is.
catops	.	.	.	×	×	×	×	.	×	×	×	×	×	.	.	×	×	×
phorcas	.	.	.	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.
scylla	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.	.	.
macrops	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
selene	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
bioculatus	.	.	.	×	.	×	×	.	×	×	×	×	.	.	.	.	.	.
gorgo	.	.	.	×	.	×	×	.	.	×	.	×	.	.	.	.	.	.
dina	.	.	.	×	.	×	.	.	.	×	.	.	.	.	.	.	.	.
domitilla	.	×	.	.	.	×	.	.	.	×	×	×	.	.	.	.	.	.
onolaus	.	.	.	×	.	.	.	.	.	×	×	×	.	.	.	.	.	.
honrathi	.	.	.	×	.	×	×	.	×	×	×	.	.	.	.	.	.	.
montana	.	.	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.
hyperbolus	.	.	.	×	.	×	×	.	×	×	.	×	.	.	.	.	.	.
dioptrica	.	.	.	×	.	×	×	.	×	.	.	.	.	.	.	.	.	.
myops	.	.	.	×	×	×	.	.	×	×	×	×	×	.	.	×	×	.
mailua	.	.	.	.	.	.	.	.	.	.	×	.	×	.	.	×	×	.
cyclops	.	.	.	×	.	×	.	.	×	×	.	.	×	.	.	.	.	.
chionides	.	.	.	.	.	.	.	.	.	×	×	×	.	.	.	.	.	.
alocus	.	.	.	.	.	.	.	.	.	×	.	.	.	.	.	.	.	.
horsfieldii	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
butleri	.	.	.	.	.	.	.	.	.	.	×	×	×	.	.	.	.	.
dimona	.	.	×	×	×	×	×	.	×	×	.	×	.	.	.	.	.	.
diana	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
urania	.	.	×	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
artemis	.	.	.	×	×	×	×	×	×	×	×	×	×	.	.	×	×	×

The Secondary Sex Characters and Scales.

The various male secondary sex characters which are a prominent feature throughout the Amathusiidae occur in the genus *Tenaris* on the upperside of the hind wing as patches of specialized scales associated with a hair-brush and hair-streak related to their various positions. These scales do not resemble in form the familiar androconia of palaearctic butterflies, but I think there can be little doubt that they are androconial in function. Their distinction from the ordinary wing scale is very marked, both in form and structure, being thick, opaque, and somewhat granular, with only in a few cases some indications of structure near the point of attachment. They occur, first, in the costal area on vein 7 beyond the junction with vein 6, where they cover a small area on and around the vein, their centre being slightly depressed; on the underside this shows as a slight swelling on the vein (Plate II, fig. 1). When the scales are removed, some species show a series of white irregular nodular enlargements on the membrane at the side of the vein, which contain a white wax-like substance; as this is not common to all the species examined, its essential function may be questioned.

The scales in this position, which I describe as the "gland," are small and uniform in shape, being either elongate-linear or hair-like, according to the species; the colour is either light brown or almost black. Directly below the gland, on the lower side of the cubitus, there is a brush of hairs long enough to reach and cover the gland, in which position the brushes are generally found on dead specimens. In some, however, they are extended as a tuft standing out on the wing, in which position, during life, they would disseminate any scent or emission they may have received from the gland. As far as I know, no scent is recorded, nor did I notice any when capturing *T. urania*. It may be noted that the inner margin of the fore wing of the male has adjacent to the base and above the gland a convex extension or flap, beyond which the margin is somewhat concave, extending again at the tornus; on the underside above the gland is a speculum. In the female this edge is always straight.

This feature is not confined to *Tenaris*, but occurs in other genera of Amathusiidae, and also in some of the Satyridae. However, I have described it as it occurs in that genus.

The second position in which these scales occur is below the hair streak, near the anal margin, internally adjacent to the 2nd anal vein, or 1*a*, and about midway along the vein (see fig. 1). They assume the form of a definite patch of very closely and somewhat irregularly packed scales, the boundary of which is generally well defined, but an extension of modified scales somewhat similar in form exists on both sides, generally not spreading very far over the wing.

The specialized scales assume three different forms: (1) elongate-oval, obtuse, with a broad shallow apical notch (Pl. II, fig. 3; Pl. III, figs. 1*a* to 4*a*), but scales with a rounded apex may occur among them; (2) oval, with a rounded apex, the sides having a greater curvature than those of No. 1, white (Pl. II, fig. 2; Pl. III, figs. 5*a* to 7*a*); (3) elongate-lanceolate, with an acute or blunt apex; among these scales, which may be called the distinctive type, others occur which are smaller and less distinctive (Pl. II, fig. 4; Pl. III, figs. 8*a* to 16*a*).

The hairs that cover the streaks vary in colour from shades of brown to dark grey and white. On the interspace beyond vein 1 a second hair-streak often occurs, but as this is variable and sometimes absent, it appears to be of minor significance ; however, in some cases its presence or absence is of sufficient importance to be of value in distinguishing the races. Each distinctive type of scale is constant in a particular species, and in each case coincides with a certain type of male armature ; this fixed relationship gives confidence in using these scales in the classification of the species.

The colour of the scales is either very dark brown, appearing black, light brown, or white. I have been unable to distinguish any difference, other than colour, between the white and black scales, when examined under high magnification or when mounted in Canada balsam.

This difference in colour has been used by Fruhstorfer, who divided the genus (*Macrolep.* 9) into two groups, namely those species having the black patch and those without it. This is a ready help in identifying some species, but Fruhstorfer failed to recognize the light brown, which, in consequence, is obscured under white or black.

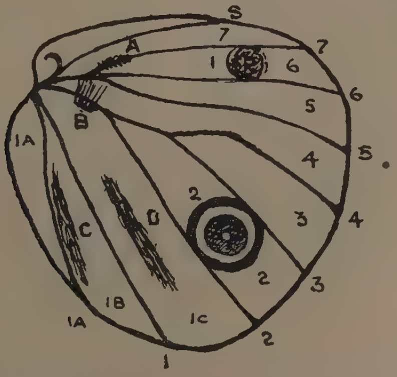

FIG. 1.—Hind wing, upperside, showing veins and interspaces, and the position of the specialized scales and hair-streaks, as described in the text.

A. The " gland " on vein 7.

B. Hair-brush.

C. Hair-streak above the specialized scales.

D. 2nd hair-streak.

Ocellus, No. 1, as it shows through from the underside, the normal position.

Ocellus, No. 2, the normal ocellus, as it occurs above and repeated below.

The specific significance of this difference in colour is extremely puzzling for it does not depend on the ground colour, and yet is constant to a race. In *T. butleri* the ground colour is deep brown, and below the anal hair-streak and continued in line with it there is always an elongate spot of white specialized scales. Pure white, except on *bioculatus*, *gorgo* and *dina*, seldom occurs ; there is generally a light brown tinge. The races of some species, especially of *artemis*, change from an apparent white to light brown on a white wing.

The variation in colour and form of this patch is considered in detail under the review of the species.

Male Genital Armature.

In the examination of these organs I have used the dry method, as practised by Brigadier W. H. Evans in his work on the HESPERIIDAE. This method has the advantage of being speedy, and leaves the organs in their natural position.

The three organs, uncus, gnathos and clasp clearly show the conspicuous differences which exist between the species and on which I have based the classification.

Drawings have been made to illustrate the dorsal, lateral and internal aspects of the majority of the species; when the clasp is the only organ which shows variation this is alone represented. While I fully appreciate the importance of aedeagus and saccus, these organs are not readily seen by the dry dissection method and remain opaque and much embedded; the aedeagus, however, shows some variation, but the saccus appears to be much the same throughout the genus. Throughout the genus the male genitalia conform to a single common pattern, from which departure occurs only in the details.

The form of the uncus is variable and difficult to describe with exactness, but the limits of variation are comprehended by the three classes in which I have arranged them. In some species it is found bent over the anus, nearly or quite on a plane with the gnathos, a peculiarity more frequent in some species than others, for instance *rothschildi* and *dioptrica*, but not confined to them, nor present even in a majority of the specimens.

The gnathos may be considered to consist of two parts, the base and the elongated portion which I term the "digit." The base is the thickened portion attached to the uncus and outwardly by a membrane to the wall of the cavity, and appears in two forms, simple and complex. The simple form is symmetrical, rounded or somewhat flat on the upperside; the complex type has the inner edge folded over to the outer side just below the attachment of the digit (Pl. VIII, figs. 80, 81). This fold is variable, and in some species, when viewed laterally, appears as a projection or spur. The length of the digit varies with the species; it may be slender, pointed or spatulate at the summit; and a somewhat spatulate form may occur among species in which it is otherwise slender. In the species mentioned in the table as having the digit spatulate it is prominent and of constant occurrence. Two remarkable forms have been found, namely, in *dina* in which it is bifurcate, and in *butleri*, in which it is stout and spoon-like in shape.

The clasp is always winged on the dorsal side only, and subtended by a neck or column of varying thickness and length, which may or may not be expanded at the apex, and always carries some claws; where the claws are small there is often variation in the shape and size, but when large, as in *artemis*, they are a very constant and reliable feature. The base of the clasp may be simple or complex; in the latter case there is a cavity usually surmounted by a flange or projection, which, when viewed from the rear, appears as a spur.

The Neuration and Wing Form (Plate IV).

Generally the neuration of *Tenaris* closely resembles that of *Faunis*. With the exception of *bioculatus* the relation of the nervures of the fore wing to one another is similar throughout the genus. In *bioculatus* vein 5 springs from the discocellular near 4 with a long interval between 5 and 6, the latter being near vein 7, and the cell is long and has the usual acute apex terminated abruptly by the vein joining 4 and 5, whereas all the other species have this section of the discocellular long and directed toward the termen so as to form an angle of varying acuteness. The length and shape of the cell varies with the species and has some influence on the wing form; the extreme instance is *horsfieldii*, with a long narrow wing following a long narrow cell with an extended apex.

The wing form is variable, but fairly constant within each species or nearly related groups of species. The amount of variation within the specimens in a series renders it unwise to regard the form of the wing as a certain indication of relationship; perhaps the most consistent similarity of form exists in the *catops* and *artemis* groups, but even here *catops dampierensis* (which is also exceptional in other respects), has a noticeably bolder round apex and outer margin than any other race.

The hind wing is more uniform with no conspicuous variation in the nervures, but *horsfieldii* differs from the other species in the length of vein 7 and especially 8, which are short and cause some difference in the shape of the costal margin.

The Ocelli and their Aberrations.

In descriptions of *Tenaris* the ocelli claim attention both as normal and abnormal features; often their specific value (especially in cases of abnormality) has been overrated. There can be no doubt that the ocellus is an important taxonomic character, and it is also probably of some protective value to the insect. Only one abnormal specimen has been found in which no ocelli are present, namely *Tenaris horsfieldii* ab. *acosmeta* Brooks (1944, *Proc. R. ent. Soc. Lond.* (B) **13** : 109), but *T. horsfieldii* is in any case a somewhat isolated species.

The complete ocellus comprises a white spot in a black pupil with a surrounding yellow ring generally enclosed by a dark area of varying width; these components are subject to great modification or even elimination; in some specimens there remains only a large circular yellow spot. Most of the extreme modifications occur only on the hind wing upperside. When the pupil is blue instead of black, it seems reasonable to regard this as the extension of the blue scales which are developed to varying degrees in many ocelli, to the complete exclusion of the black. But I can offer no explanation of the remarkable replacement of the usual yellow ring by a blue one in *Tenaris bioculatus*. The variation in the size of the ocellus may be considerable in some races, whereas in others it may be negligible, irrespective of the species. Throughout the genus the occurrence of the ocelli is irregular, except in one position which will be referred to later, but in each species a certain definite number and location appears to be normal for that insect, any additional ocellus being aberrant.

In the following descriptions of the positions occupied by ocelli I have used the number of the vein interspace in which they occur, as shown in the figure illustrating the positions of the secondary sex characters (fig. 1).

On the fore wing of the normal insect ocelli are absent, except in *Tenaris butleri*, which has two on the underside in spaces 2 and 3, but the casual appearance of an ocellus in any species is not infrequent on both sides or only below (ab. *sidus* Stichel).

On the upperside of the hind wing the anal ocellus may appear irregularly and when it occurs it will occupy space 2, in some species it is duplicated in either of the spaces directly above or below ; in a few races, and not always throughout the species, an ocellus in space 6 may be present, but where it appears casually it is abnormal (ab. *duplex* Stichel).

On the underside of the hind wing there is always an ocellus in space 6, and in the majority of the species another occupies space 2. It is of interest to note that the former is always present and apparently of primary importance in the genus ; this is shown by the species and aberrations in which space 2 is unoccupied ; it is curious that on the upperside the importance of these positions is reversed. In species and aberrations which have a duplicated anal ocellus one of these will be in space 2.

Three ocelli appear to be the maximum number which occur normally, but a larger number of species have only two, with additional aberrational ocelli ; according to the interneural spaces, eight are possible, but no specimen has been found with more than six (ab. *prodiga* Fruhstorfer), which appears to be the limit ; also, the chain of ocelli only extends from space 1*c* or 2 to 6 or 7 ; should space 7 be filled, space 1*c* will be empty ; should space 7 be empty, 1*c* will be filled.

The most frequent additional ocelli occur as duplications of the primary ocelli in spaces 2 and 6, as separate aberrations, the former being named ab. *opulenta* Stichel, the latter ab. *lacrimans* Fruhstorfer. These names do not distinguish which adjacent space is occupied, above or below ; in this respect, descriptively, they are incomplete and serve only to distinguish a common type of aberration. But as so many variations occur and the matter is complicated by their asymmetric occurrence, to name them separately is of little use. This should be remembered by those who may be tempted to name an unfamiliar aberration.

There seems to be some curious ability to produce an ocellus to cover some injury which has occurred to the veins, presumably during the pupal state. Four examples have been noted in different species. As they are of interest I am describing them in detail :

(1) *Tenaris uranus* L. ♂. The left wings are normal, also the fore wing on the right. Right hind wing upperside : Veins 5, 6 and 7 anastomose mid-way in their length, 5 and 7 curving over to join vein 6, below the junction vein 6 disappears for about 2 mm. then continues normally to the margin, while 5 and 7 again curve outwardly to their normal positions on the margin. Above the junction of the veins there is a small somewhat indistinct oval ocellus, having its dark centre directly over the junction, surrounded by a yellow and outer dark border ; this ocellus is not directly over that on the underside in space 6, which is normal. The scales of the ocellus radiate from the centre, which distinguishes them from the normal straight rows.

(2) *Tenaris catops*. ♀. Left hind wing underside : The veins are normal except 3 and 4 which curve towards one another and are linked by a short cross vein at about half the length of 4, then curve outwardly to their normal position on the margin. In space 2 the normal ocellus is present but misshapen ; on the opposite side of the junction in space 4 there is an elongate black spot, presumably an ocellus. Both ocelli are contained in a yellow zone extending from vein 2 to beyond 5, bordered inwardly by a dark line. On the upperside, directly above the injury, there is a patch of yellow scales, which is absent from the opposite wing, which has no ocellus.

(3) *Tenaris domitilla agrippa* Fruhstorfer. ♂. The right hind wing is normal with two ocelli in spaces 2 and 3. The left hind wing has one abnormally large anal ocellus completely filling spaces 2 and 3 directly over the position of vein 3, which disappears just above the ocellus, and is continued below the black pupil to the margin.

(4) *Tenaris verbeeki* f. *theon* Brooks. ♂. The left hind wing is normal, without ocellus on the upperside, as appears to be the rule throughout the species. On the right wing in space 2 is a small hole, slightly below the ocellus on the underside, which is normal; this hole has damaged vein 2. Adjacent to the hole is a small group of dark scales with an irregular yellow surround which is again enclosed by a border of dark scales suffusing the internal side of the white ground colour. There is some extension of the yellow area into space 1*c* having the appearance of an incipient second ocellus.

The Classification of the Species.

The arrangement of the species to show their relationship one to another is difficult and rests sometimes on such slight characters that doubt must remain as to their value. Nevertheless, I believe my tentative arrangement based on these characters to be a nearer approach to the truth than has hitherto been achieved.

I consider the male sex armature of primary importance, and arrange the species in the order of its complexity, assuming that the simplest should come first. Whenever so much variation in the armature has been found among the specimens of a race that it is difficult to decide which is the typical form and ample material for dissection has been attainable, I have selected that which appears to be the average form; in exceptional cases of extreme variation several forms are shown, especially in the case of *artemis*.

The wing form and pattern in some species clash with more important characters, and being also very variable have only been taken into consideration (other than among the races of a species) where they are fairly constant. This variability of wing shape in many cases appears to be due to some geographical influence, the aptitude to change when the habitat is changed being shown throughout the genus; thus, one finds great dissimilarity of wing pattern arising from isolation over long periods. Further, species occur having dimorphic sexes, each sex resembling a different species, as for example in *montana*, *hyperbolus* and *dioptrica*. It is true that I may not always have assigned these females to their proper males, there being no records of pairs taken in coition, but the assumptions appear correct.

Regarding the secondary sex characters, especially the specialized scales which I have reviewed at some length, it is of interest to follow the form of these scales relative to the species and the indications they give as to their affinities.

It will be seen from the Table of Classification that certain species have many features in common, so that their affinities are not in doubt; others are more distant, but still clearly connected with each other, while some species have only one or two characters connecting them with those preceding and following; these are the most difficult to place. In the following section the relationships are briefly discussed; generally the similarity or difference can

TABLE II.—*Table of Specific Characters.*

Species.	Male genital armature.												Specialised scales.					Venation.	
	Uncus.			Gnathos.				Clasp.					Gland.		Below the hair-streak.				
	Long slender.	Short or mid-short	Short and very stout.	Simple.	Complex.	Very distinctive.	Broadly spatulate.	Simple with no process at base.	Complex with cavity and flange.	Wing wide.	Wing narrow.	Summit curved with large claws.	Elongate-linear.	Hair-like.	Elongate - ovate, round or retuse apex.	Elongate-ovate.	Elongate-lanceolate.	Normal.	Abnormal.
1. *T. catops*	.	×	.	×	.	.	.	×	.	.	×	.	×	.	×	.	.	×	.
2. *T. phorcas*	.	×	.	×	.	.	.	×	.	.	×	.	×	.	×	.	.	×	.
3. *T. scylla*	.	×	.	×	.	.	.	×	.	.	×	.	×	.	×	.	.	×	.
4. *T. macrops*	.	×	.	×	.	.	.	×	.	.	×	.	×	.	×	.	.	×	.
5. *T. selene*	.	×	.	×	.	.	.	×	.	.	×	.	×	.	×	.	.	×	.
6. *T. bioculatus*	×	.	.	×	.	.	.	.	×	×	.	.	×	.	.	×	.	.	×
7. *T. gorgo*	.	.	×	×	.	.	.	.	×	×	.	.	×	.	.	×	.	×	.
8. *T. dina*	×	.	.	×	.	×	.	.	×	×	.	.	×	.	.	×	.	×	.
9. *T. domitilla*	×	.	.	.	×	.	.	.	×	×	.	.	×	.	.	.	×	×	.
10. *T. onolaus*	×	.	.	.	×	.	.	.	×	×	.	.	×	.	.	.	×	×	.
11. *T. honrathi*	×	.	.	.	×	.	.	.	×	×	.	.	×	.	.	.	×	×	.
12. *T. montana*	×	.	.	.	×	.	.	.	×	×	.	.	×	.	.	.	×	×	.
13. *T. hyperbolus*	×	.	.	.	×	.	.	.	×	×	.	.	×	.	.	.	×	×	.
14. *T. dioptrica*	×	.	.	.	×	.	.	.	×	.	×	.	×	.	.	.	×	×	.
15. *T. myops* (*rothschildi kirschi*)	×	.	.	.	×	.	.	.	×	.	×	.	×	.	.	.	×	×	.
16. *T. mailua*	×	.	.	.	×	.	.	.	×	×	.	.	×	.	.	.	×	×	.
17. *T. cyclops*	×	.	.	.	×	.	.	.	×	.	×	.	×	.	.	.	×	×	.
18. *T. chionides*	×	.	.	.	×	.	.	.	×	.	×	.	×	.	.	.	×	×	.
19. *T. alocus*	×	.	.	.	×	.	.	.	×	.	×	.	×	.	.	.	×	×	.
20. *T. horsfieldii*	.	.	×	.	×	.	.	×	.	×	.	.	.	×	.	.	×	×	.
21. *T. butleri*	×	.	.	.	.	×	×	.	×	×	.	×	.	×	.	.	×	×	.
22. *T. dimona* (*microps*)	.	×	.	.	×	.	×	.	×	×	.	×	.	×	.	.	×	×	.
23. *T. diana*	.	×	.	.	×	.	×	.	×	.	×	×	.	×	.	.	×	×	.
24. *T. urania*	.	×	.	.	×	.	×	.	×	×	.	×	.	×	.	.	×	×	.
25. *T. artemis*	.	×	.	.	×	.	×	.	×	.	×	×	.	×	.	.	×	×	.

be followed by referring to the table, so that separate mention of these features is unnecessary, but when extended explanation is required it will be found in the review of the species.

When the table of specific characters (Table II) is considered in conjunction with the geographical distribution of the species, it will be noticed that three dominant groups exist, the species constituting these groups being characterized by great similarity of characters and a very extended distribution. As names for these groups I have selected the oldest included specific names, i.e. (1) *catops* (Species, Nos. 1 to 5), (2) *myops* (Nos. 9–19), (3) *urania* (Nos. 23–25). The distribution of these species in each case covers nearly the whole range of the genus, and extends beyond that of the remaining species. It is speculative, but there appears to be some reason to suggest that these are the three main evolutionary lines in the genus and that from this vigorous stock the remaining species are derived. Minor changes are clearly shown within these groups, especially among the species of *myops* ranging from *domitilla* to *alocus*. From this one may surmise that the order of evolution, in time, was first the simplest *catops*, later *myops* and *artemis*, with others appearing at various stages.

Classification.

T. catops, *phorcas*, *scylla*, *macrops* and *selene*.—These species form a very homogeneous group, having the simplest male sex armature, as shown by both the gnathos and clasp, and also the distinctive form of specialized scales. The clasp in its elongate form with the small wing at the base is found only in these species.

T. bioculatus, *gorgo* and *dina* are three distinct species, each having a unique feature: *bioculatus* has a venation strange to *Tenaris*; *gorgo* has a curious finger-like projection at the apex of the clasp; *dina* is distinguished by the forked gnathos. The salient features connecting these species to each other are (1) the specialized scales under and around the anal hair streak on the hind wing, in each case pure white (which is exceptional), and in form somewhat elongate-ovate varying slightly in the different species, suggesting those found in the *catops* group. As far as I can see there is no massed grouping of these scales as in the other species, and they appear to be spread regularly in the space between veins 1*a* and 2. (2) The base of the gnathos is simple, similar to that of the preceding and unlike that of the following species. The clasp has the form and structure of the succeeding species; thus they appear to be connected on the one hand with the *catops* group, on the other with the remainder, excepting *horsfieldii*, which has the base of the clasp simple.

The succeeding 14 species have many features in common which distinguishes them as a group, but a closer relationship again exists among some of these species, thus forming subgroups. The relationship of these subgroups to one another is confusing, for although these species are distinct there is little guidance as to their priority or the relative positions they occupy. The following arrangement appears to be legitimate:

T. domitilla, *onolaus* and *honrathi*.—Although *domitilla* differs widely in wing pattern from the other two, the fore wing of the male of each species is uniformly coloured, and the females follow this type. Other characters point to their relationship.

T. montana, hyperbolus, dioptrica and *myops.*—The wing pattern of the female is similar in the four species, but the first three have dimorphic sexes, the males following the males of the former group, while the male of *myops* resembles the female; at the same time *dioptrica* and *myops* approach each other more closely than the other two species.

T. mailua and *cyclops.*—The wing pattern of these species resembles that of *myops*, but differences in the male sex armature are distinctive. The specialized scales under the hair-streak on the hind wing in all three species are light brown with an indefinite margin, and distinct from *myops*.

T. chionides and *alocus.*—The two species are closely related to each other. but distinct from *cyclops*. Obviously they belong to the group, but occupy a somewhat isolated position.

T. horsfieldii.—Differs from the other species in venation and in the genitalia in both sexes. The male genitalia are very stoutly built and there is no process at the base of the clasp, which thus resembles that of *catops*. The specialized scales both on the gland and under the hair-streak on the hind wing are similar to those of *artemis*. This combination of simple and complex characters appears to indicate an intermediate position; while in general it belongs to the preceding species there are features which favour *artemis*.

T. butleri.—A very distinct species, in status somewhat similar to *horsfieldii*, but with more characters in common with *artemis*.

T. dimona.—A distinct species which cannot be grouped with any other; also favours the *urania* group.

T. diana, urania and *artemis.*—These species differ in many features from those previously mentioned, but among the three there are many characters in common, indicating a common affinity.

A Key for the Separation of the Species of *Tenaris.*

This key is founded on the revised arrangement of the species in which *montana* is withdrawn from *onolaus* and recognized as a good species, also *mailua* from *kirschi*, while *rothschildi* and *kirschi* are considered as subspecies of *myops*, and *cyclops* accorded full specific rank.

No consideration is given to the ocelli, except when they are of specific value for determination of the species and races. Aberrant specimens are not distinguished by this key, but otherwise there should be no difficulty in placing the males and most of the females. The wings patterns of the ♂ and ♀ are similar in many species, and in these cases the two sexes are indicated after the specific name.

PRIMARY CHARACTERS.

Separation of the sexes.

The inner margin of the fore wing convex near the base and curved to the tornus; hind wing upperside with a hair tuft on the lower side of of the cubitus near the base and a gland on vein 7; a hair-streak on the anal margin, covering a patch of specialized scales . . . Males.

The inner margin of the fore wing straight; no such secondary sex characters on the hind wing . . . . Females.

Separation of Tenaris phorcas.

Body brown . . . . *Tenaris phorcas.*
Body yellow . . . . All other species.

Separation by wing pattern.

Fore wing upperside inner margin white (or slightly dusky) as far as the tornus; white area extending to or beyond the cell[1] . . . . . . A.

Fore wing upperside inner marginal white area not reaching tornus, which is reached by the dark outer marginal border . . . . . . AA.

Fore wing filled with colour but lighter[2] internally from the inner margin . . . . B.
Fore wing filled with a uniform colour which does not exclude a narrow white or light edging on the inner margin . . . . C.
Fore wing with a dark band across the inner margin, varying in width; it may barely reach vein 2, or almost fill the wing, in which case the white area below the apex is reduced to a more or less enclosed spot . D.

Male secondary sex characters.

The scales under the anal hair-streak[3] on the hind wing :[4]

(1) Pure white . . . . a.
(2) Near white or very light brown. . . . . b.
(3) Light to dark brown, the patch often small, the boundary generally suffused and tinged with reddish brown . . c.
(4) Black or deep black-brown, the area of the patch somewhat extended, with a very definite boundary . . . d.

Confirmatory characters.

Aa 1. Hind wing upperside: ocellus absent or very rarely indicated by a spot; outwardly more than half filled with grey or black, with no indication of a definite border and diffused into the basal white. Underside both apical and anal ocelli present, the latter often duplicated and suffused with blue. In the ♂ the fore wing subcostal delicately feathered *gorgo* ♂, ♀.

2. Hind wing: blue anal ocelli in spaces 1 and 2, above and below; sometimes in the ♂ the ocelli above with a slightly yellow surround. Underside, both sexes, a prominent yellow ocellar band curving round the outer half; the apical ocellus complete . . . . *dina* ♂, ♀.

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[1] Note on wing pattern "A": There are a few rare forms of *myops* and *artemis* which may be included or mistaken for "A." These specimens have either a greyish-brown lightly suffused area on the fore wing (*myops*), or a red-brown area (*artemis*). The former is distinguished from *chionides* by the wing shape, also the males are separated by the anal hair-streak scales.

[2] In the female of *dimona, scylla, macrops* and *selene* this "lighter" area is extensive, white, and occupies most of the fore wing.

[3] The colour of the hairs is not taken into consideration.

[4] In *bioculatus* they are often mixed with dark or black scales and the hairs above are coloured grey-brown to grey.

3. Hind wing: anal ocelli, above and below, in spaces 1 and 2, surrounded by a blue ring, which replaces the yellow of all other species. Fore wing vein 6 near 7, with a long interval between 5 and 6 . . . . *bioculatus*, ♂, ♀.

Ac 4. Fore wing: outer margin rounded, and at least the lower half of the wing white, extending on the inner margin, and more or less on the outer margin from the tornus . *catops*,[5] ♂, ♀.

5. Fore wing ♂, long and somewhat narrow, the outer margin slightly concave. Both sexes, a narrow dark costal border not extending to the apex. There is generally a suffused dark area at the base below the cell. Hind wing upperside, basal half filled with orange . . . . *chionides*, ♂, ♀.

6. Similar to *chionides* but the fore wing costal band always weakly greyish, and reaching to, and expanding (more or less) at the apex. Hind wing upperside outwardly surrounded by a greyish border suffused inwardly . . *cyclops*, ♂.

7. Hind wing upperside: ocelli blue with a lighter blue iris in spaces 2 and 3; that in space 3 is often very small. Underside the anal ocelli enclosed in a yellow surround *dimona*, ♂, ♀.

AAa Characters as No. 3 . . . . *bioculatus*, ♂.

AA ♀♀. Characters as Nos. 7, *dimona*; 9, *scylla*; 10, *macrops*; 11, *selene*.

AAb. 8. Hind wing upperside: generally only one anal ocellus in space 2. Underside ocelli in spaces 1 and 2. The ocellus above and below is very prominent, the yellow ring being as wide as, or wider than, the black centre . . . *diana*, ♂, ♀.

Ba Characters as No. 3 . . . . *bioculatus*.

Bd 9. Fore wing and hind wing underside: the basal third of the former and half of the latter, dark brown, thus dividing the wing vertically. Underside below the anal ocellus there is often a narrow yellow area extending to the margin *scylla*, ♂, ♀.

10. Fore wing and hind wing border reddish dark brown. Hind wing a very prominent ocellus above and below, with a wide yellow ring, which on the upperside is nearly as wide as the dark centre, also a dark outer ring; the distance of the centre of the ocellus from the wing margin ranges between 8 and 11 mm. in the ♂, and 9 to 12 mm. in the ♀. The brown outer margin broad, internally white *macrops*, ♂, ♀.

11. Similar to *macrops*, but larger; in some specimens the yellow ring of the ocellus is not so wide, and the hind wing border less defined. Distance from the centre of the anal ocellus to the margin ranges between 11 and 14 mm. in the ♂ and 14 and 16 in the ♀ . . . . *selene*, ♂, ♀.

12. The sharply defined boundary and somewhat extended area of the black scales of the anal hair streak are the most definite features of determination. Hind wing underside, a wide dark border completely surrounding the wing *dioptrica* ♂.

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[5] These are white forms of *catops* (*tordula*, *mylaechoides* and *mylaecha*) with only dark outlines of the veins below the costal margin on the ♂ and a narrow costal border on the ♀. These are distinguished from other species by the round apex, outer margin and tornus of the fore wing.

Cc 13. Hind wing underside: the anal ocellus has the yellow ring extending on one side to the tornus, as though pulled out of shape, or it may be extended more or less over the anal area but never more than half-way to the base, ♂ and ♀. In some cases the ocellus and rings are normal, in which case *honrathi* can be distinguished from ♂ *hyperbolus* and ♂ *dioptrica* by the white hairs on the submedian space of the upperside, or by their absence. In the two latter forms these hairs are tinged with brown (sometimes white in the rare albinic forms of *dioptrica*). In contrast to *macrops* the colour of the fore wing is greyish-brown, and the border of the hind wing somewhat inconspicuous . . *honrathi*, ♂, ♀.

Cb 14. Fore wing and cell very long. Hind wing: vein 8 short, a prominent anal ocellus above and below. The circular yellow area which surrounds the ocellus extends outwardly; internally it may be almost absent; there is no brown outer ring . . . . *horsfieldii*, ♂, ♀.

15. The ground colour of both wings dark brown. Fore wing underside, two ocelli. Hind wing upperside: ocelli in spaces 1 and 2 . . . . *butleri*, ♂, ♀.

16. Fore wing large and wide, the angles rounded. Hind wing upperside: the anal ocellus has a large black centre with the yellow ring about one-fourth the width of the complete ocellus . . . . *urania*, ♂.

(8) Characters as No. 8 . . . . *diana*.

17. Similar to *onolaus*, No. 20, but the fore wing light grey and not more than 88 mm. long . . . . *montana*, ♂.

18. Colour and marking near *dioptrica*, ♂, No. 12, but distinguished from it by the smaller dark brown and not sharply bounded patch of hair-streak scales. Hind wing upperside: a conspicuous patch of light brown hairs below the submedian . . . . *hyperbolus*, ♂.

(10) Characters as No. 10 . . . . *macrops*.

Cd 19. Hind wing: prominent anal ocelli in spaces 2 and 3, showing above and below, both enclosed in the yellow surround *domitilla*, ♂, ♀.

20. Hind wing underside: the anal area surrounded by a prominent orange-yellow area, often filling the anal angle and extending to the base . . . . *onolaus*, ♂, ♀.

21. Fore wing upperside: the colour appears slightly lighter below the apex. Hind wing underside: the marginal border in the anal angle thin or broken *myops fergussonia* f. *crus*, ♂.

Db 22. Hind wing upperside: a yellow area below the base. Underside, the costal border terminates at the base with no expansion around or into the wing . . . . . . *artemis*, ♂.

23. The marking on both wings dark grey or black. Underside: the anal ocellus has no dark outer ring, thus distinguishing it from *myops* . . . . *mailua*, ♂, ♀.

Dc 24. Fore wing approximately twice as long as wide, the outer margin concave

(i) Fore wing: white area generally wide, with a narrow costal border expanding at the apex *cyclops* ♂ (except *c. cyclops*).

(ii) Characters as No. 5 . . . . *chionides*, ♂.

(iii) Hind wing upperside: no light brown area at tornus *cyclops*, ♂.

25. Fore wing upperside: the band across the wing is narrow and light brown. Hind wing upperside: a light brown area at the anal angle. . . . . *alocus* ♂.

Dd (12) Fore wing upperside: the border on inner margin not well defined; the colour may be faint and silver-grey . *dioptrica*, ♂ albinic forms.

26. Scale patch as in *dioptrica*. Fore wing shows very wide variation in the extent of the white area in different races; it may be rather small and placed obliquely below the apex, or very wide and bounded outwardly by a horizontal band. Hind wing underside: the dark forms have wide dark borders with a continuation of the costal border around the base; in the light forms (*rothschildi*) the costal border terminates at the base . . . . *myops*, ♂.

D ♀ (16) The wings large and rounded outwardly. Fore wing: the white area divided by darkly outlined veins into three or four sections; otherwise as No. 16 . . . . . . *urania*, ♀.

(17) Hind wing upperside: the marginal border tapers from the apex to the tornus. Underside: the anal area from the base to the tornus orange yellow . . . . *montana*, ♀.

(5) Hind wing underside: the costal border dark brown to black *chionides*, ♀.

(25) Hind wing underside: the costal border greyish-brown, and on the fore wing underside a still lighter brown *alocus*, sp. n. ♀

(12) Hind wing upperside: the outer marginal border very broad, not tapering to the tornus; sometimes filling the wing; the hairs below the base white or dusky. Underside: a wide expansion of the costal border around the base *dioptrica*, ♀.

(18) Upperside similar to *dioptrica* but the colour a redder brown. Hind wing: the hairs below the base light brown or yellowish. Underside hind wing: the marginal border complete and wide . . . . *hyperbolus*, ♀.

(22) Hind wing upperside: a yellow area below the base. Underside: the costal border ends at the base with no expansion, the marking generally light . . . . *artemis*, ♀[6].

(6) Fore wing: the border on the inner margin, and hind wing outer border light greyish brown, also on the underside. A yellow area extends from the base to the tornus *cyclops*, ♀.

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[6] Females of some of the races of *artemis* (22) and *myops* (26) so closely resemble each other that it is impossible to describe characters which separate them; also those of *myops* (26), *dioptrica* (12) and *cyclops* (24), have differences so slight as to be confusing and only well seen in a good series of specimens.

Systematic account of the species of *Tenaris*.

All the material listed in the following account of the species, races and forms of *Tenaris* is in the British Museum (Natural History) unless otherwise stated.

References to original descriptions will be found in Stichel, 1933, *Lep. Cat.* 54, AMATHUSIIDAE, or, if later than 1933, by reference to the bibliography (p. 237).

Tenaris catops Westwood (1851).

Genitalia, Pl. VI, figs. 1, 2, 3. Specialized scales, Pl. III, fig. 2. From a consideration of the numerous specimens of *catops* in the Museum, and that nearly each subspecies is represented by fairly long series, some being very common, one arrives at the conclusion that this is the commonest species of *Tenaris* found in New Guinea, and that it possesses great vigour ; its wide distribution and great variation in wing pattern corroborate this. The range extends from Gebi and adjoining islands in the west, over the mainland to Sudest Island in the south-east.

Under the varying physical and climatic conditions thus encountered it is, perhaps, the most complete example of geographical variation in the genus. These geographical variations have resulted in the description of 27 subspecies, and several forms, though probably some of the former should be placed among the latter, their position being doubtful.

Aberrations of the ocellus are numerous and varied, occurring irregularly in the different races, chiefly on the upperside ; below, the ocelli are more stable, but often in the same race they differ in size. The anal ocellus on the upperside is generally well developed in specimens from the western islands and mainland ; in the eastern races it is often absent, or appears only as a point ; the brown pupil is always small, the yellow iris varies from a small to a very prominent circle, the brown containing ring being generally absent or only slightly indicated.

Summary of the Subspecies.

Tenaris catops gebiensis subsp. n.

Above, this insect does not differ from *selenides*, but on the hind wing underside the border is more consistently wider, with slightly smaller and more uniform ocelli.

Habitat : Gebi Island, 13 ♂, 6 ♀.

Tenaris catops selenides Staudinger (1888).

Habitat : Waigeu, 19 ♂, 16 ♀.

Tenaris catops jathrippa Fruhstorfer (1915).

Habitat : Salawatti, 4 ♂. 1 ♂ from Letti Island (*Forbes*) has a narrower border on the hind wing than those from Salawatti.

Tenaris catops fulvida Butler (1870). Genitalia, Pl. VI, fig. 1.

Habitat : Mysol Island, 17 ♂, 18 ♀.

Tenaris catops laretta Fruhstorfer (1904).

Habitat: Sorong, 10 ♂.

Tenaris catops pamphagus Kirsch (1877).

Habitat: Manokwari, 2 ♂, 4 ♀; Dorey, 53 ♂, 32 ♀; Momi Coast, Arfak, 16 ♂, 4 ♀; Coast near Arfak, 3 ♀; Momi River, 1 ♂, 1 ♀; Angi Lakes, 6000 ft., 1 ♂; Ditschi, 3 ♂; Siwi Mt., 3 ♂; Mioswar Island, 2 ♂; Mun Island, 1 ♂; Run Island, 2 ♀; Kapaur, 33 ♂, 27 ♀; Fak Fak, 10 ♂, 6 ♀; MacClure Gulf, 8 ♂, 1 ♀; Ati Ati Onin, 2 ♂.

Tenaris catops pamphagus f. *catanea* Fruhstorfer (1904).

I have placed *catanea* as a form of *pamphagus*; it cannot be considered as a separate race in the southern part of the peninsula. Considerable variation occurs among the specimens from all the districts recorded so that it seems impossible to decide which is the normal form. Moreover, the type of *catanea* represents a dark form, of which there are only a few specimens.

Tenaris catops kajuna Fruhstorfer (1904).

Habitat: Kajumera Bay, 3 ♂, 3 ♀; Wangaar, 8 ♂, 8 ♀; Coast District Geelvink Bay, 3 ♂, 1 ♀; Wangaar, 25 miles south, 4 ♂, 3 ♀; Etna Bay, 3 ♂, 2 ♀; Triton Bay, 1 ♂, 1 ♀.

Fruhstorfer's type of this race belongs to the rarer dark form of which there are 9 males and 6 females from various districts. In the light form the costal marking is less extended, and the dirty white ground-colour clearer; a similar change appears on the hind wing and the yellow area below the base is less marked, and in some specimens is a faint tinge. In the dark form the extent of the dark marking varies, reaching the maximum in the form I described as *pellus* (Brooks, 1944). The females are also susceptible to this change but in a less degree.

Tenaris catops catops Westwood (1851). Specialized scales, Pl. III, fig. 2.

Habitat: Aru, 75 ♂, 34 ♀. There are also 3 ♂, 1 ♀ labelled Ambon, and 1 ♂, 2 ♀ Ke Islands, which appear to belong to this race; as these localities are most unlikely the labels are probably incorrect. Some of the specimens grade to the form *pellus*, of which there are 9 ♂, 4 ♀.

Tenaris catops galaecia Fruhstorfer (1914).

Habitat: Eilanden Riv., 18 ♂, 7 ♀; Upper Setekwa Riv., Snow Mts., 2–3000 ft., 9 ♂, 11 ♀; near Oetakwa Riv., Snow Mts., up to 3500 ft., 10 ♂, 3 ♀; Base Camp Utakwa Riv., sea level, 4 ♂; Canoe Camp, 1 ♂; Utakwa Riv., 2500–3000 ft., 2 ♂, 1 ♀.

Much variation occurs among these insects, chiefly in the extent of the border on the hind wing underside, in one case this completely filling the wing; however, there is no question of more than one race.

Tenaris catops vanhaasterti Hulstaert (1925).

1 ♀, placed under this name, from the Rothschild Coll., from Mt. Goliath 5–7000 ft., Dutch Cent. N. Guinea, does not differ from *galaecia*. Authentic material might reveal a difference.

Tenaris catops colarina van Eecke (1915).

Habitat: Bivakland, S. Dutch N. Guinea. This race is represented in the Museum by 1 ♂, from Bivakland, but, on the basis of the published description, I am unable to distinguish it from *galaecia*.

Tenaris catops turaica Hulstaert (1923).

Habitat: Turai, S. Dutch N. Guinea. Not represented in the Museum. Probably a form of *galaecia*.

Tenaris catops vaneeckei Hulstaert (1923).

Habitat: Merauki, S. Dutch N. Guinea. Not represented in the Museum. Probably a form of *galaecia*.

Tenaris catops turdula Fruhstorfer (1914).

Habitat: Yule Island, 4 ♂, 4 ♀ (one of the females is ab. *unipupillata* Fruhstorfer); Aroa River, 1 ♂, 6 ♀; Owgarra, Upper Aroa River, 5 ♂, 1 ♀; Dinwara, 17 ♂, 7 ♀; Ekeikei, 10 ♂, 4 ♀; Babooni, 1 ♀; Vailala River, 1 ♂; Moroko, Mt. Nisbet, 1 ♀; Angabunga River, 1 ♂; Aird Hill, 1 ♀.

The lightest form is from Yule Island, but a rare form of the female occurs with a broadly dark apex to both wings. There are similar specimens from other localities. Ocellar variation is very slight.

The two females mentioned by Waterhouse (*Butt. Aust.*) page 49, from Darnley Island, probably belong to this subspecies.

Tenaris catops jobina Fruhstorfer (1904).

Habitat: Jobi Island, 21 ♂, 5 ♀; Hattam Arfak, 2 ♂, 1 ♀.

Tenaris catops westwoodi Staudinger (1893). Genitalia, Pl. VI, fig. 2.

Habitat: Geelvink Bay to Humboldt Bay, 21 ♂, 13 ♀; Fr. Wilhelmshafen, 4 ♂, 1 ♀; Stephensort, 23 ♂, 12 ♀; Cyclops Mts., 1,200 ft., 1 ♀; Erina, 7 ♂, 3 ♀; Astrolabe Bay, 20 ♂, 10 ♀; Constantinhafen, 11 ♂, 7 ♀; Finisterre Mts., 4 ♂, 1 ♀; Finchafen, 3 ♂, 3 ♀; Simbang, 5 ♂, 2 ♀; Sattelberg, 8 ♂, 4 ♀; Rawlinson Mts., 2 ♂; Markham River, 1 ♂; Herzog Mts., 3–5400 ft., 1 ♀; Bongo, 4 ♂, 2 ♀.

This very extensive series of specimens from the area between Geelvink Bay and the eastern limit of Mandated Territory shows very distinctly the gradation of marking from the extended black in the west to reduced and more defined bands in the east, approaching *mylaechoides* of the Kumusi River. The white becomes very pure and the yellow area on the hind wing may be seen, but is not conspicuous.

Tenaris catops vulcanica Rothschild (1915).

Habitat: Vulcan Island, 8 ♂, 6 ♀.

This is a lightly marked race; there is little to distinguish it from *mylaechoides*, save a slightly brownish tinge to the white ground-colour. The female form *submylaechoides* Rothschild (1915) has narrow markings, and is of frequent occurrence among the females of the eastern races. Females occur as either one or the other, i.e. with broad or narrow marking, without intermediates.

Tenaris catops dampierensis Rothschild (1915). Pl. V and V*a*, figs. 1 ♂, 2 ♀.

Syn. *Tenaris elatus elatus* Brooks (1944).

From Dampier Island two distinct forms are recorded; one of these is indistinguishable from *vulcanica*, of which there are 4 ♂, 1 ♀, the other was described by Lord Rothschild as *dampierensis*. The published description of this insect is inadequate, and does not convey the special distinction which this form deserves. Its unique markings recall *T. phorcas admiralitatis* from the Admiralty Islands, and not being able to consult the type but only specimens resembling *vulcanica*, I fell into error in describing it as a new species. It is difficult to understand that these two forms are related to one another, especially as no similar divergence appears among the numerous specimens of *mylaechoides* and the light forms of *westwoodi*. However, one abnormal specimen from Dampier Island, ab. *subluna* Rothschild (1915), an aberration of the *vulcanica* form, favours that race; the fore wing above is similar, but with a more extended outer marginal border on the hind wing, on the underside the little difference there is favours *dampierensis*. The difference between the two forms is on the upperside; of this *subluna* gives no indication.

That *dampierensis* is a definite race is shown by 7 ♂, 2 ♀, which are remarkably uniform. The relationship of the two forms occurring together is difficult to explain. It may be suggested that the light form is a migrant from the not far distant Vulcan Island, on the other hand, if it is accepted as a form of *dampierensis* it should receive named recognition, but with the possibility of incorrect labelling I leave the question to be answered when more certain information is available.

Tenaris catops mylaechoides Fruhstorfer (1905)

Syn. *Tenaris catops kamusii* Bakker, 1942, *Zool. Medel.* **23**, Afl. 3–4, Pl. 9, figs. 3–4.

Habitat: Waria River to 2500 ft., 4 ♂, 5 ♀; Biagi, Mambare Riv., 5000 ft., 5 ♂, 4 ♀; Lower Mambare Riv., 1 ♀; Holnicote, 1 ♂; Albert Edw. Range, 6000 ft., 1 ♂, 1 ♀; Kumusi Riv., 11 ♂, 6 ♀; Hydrographer Mts., 10 ♂, 6 ♀; Collingwood Bay, 3 ♂, 1 ♀,

Tenaris catops leanas Brooks (1944).

Habitat: Port Moresby, 7 ♂, 3 ♀; Brown Riv., 1 ♂.

Tenaris catops appina Fruhstorfer (1904).

Habitat: Mailu, 8 ♂, 4 ♀; Sariba Is., 2 ♂; Samarai, 1 ♂; Milne Bay, 19 ♂, 11 ♀.

Tenaris catops adriana Fruhstorfer (1904).

Habitat: Goodenough Is., 16 ♂, 11 ♀; Fergusson Is., 10 ♂, 6 ♀; D'Entrecasteau Is., 3 ♂.

Tenaris catops fimbriata Kirby (1889).

Habitat: Normanby Is., 1 ♀; Woodlark Is., 13 ♂, 17 ♀.

Kirby's type is a female and the only specimen from Normanby Island.

As the females of these neighbouring races are so similar, and the races are distinguished from each other by difference in the male, there remains the possibility that the male from Normanby Is. differs from that from Woodlark Island.

On the upperside it is difficult to distinguish *adriana* from *fimbriata*, but on the hind wing underside *adriana* has a wide border on the costal margin, uniform in width from the base to the ocellus; on *fimbriata* this is narrower, and tapers to half its width at the ocellus.

Tenaris catops rosseliana Rothschild (1916).
Habitat: Rossell Is., 16 ♂, 22 ♀.

Tenaris catops mylaecha Westwood (1851). Genitalia, Pl. VI, fig. 3.
Habitat: Sudest Is., Louisiade Islands, 26 ♂, 16 ♀.

Tenaris catops nicasius Fruhstorfer (1905).
Habitat: Unknown. Described from one specimen in the Dresden Museum; its status is doubtful.

2. *Tenaris phorcas* Westwood (1858).

Genitalia Pl. VI, figs. 4, 5. Specialized scales, Pl. III, fig. 1.

The brown abdomen of this species distinguishes it from all other species of *Tenaris*. As far as the records show it is the only species in the genus generally distributed over the Solomon Islands and Bismarck Archipelago, which, for the purpose of this paper are considered as one group. Although *phorcas* is apparently abundant, the numbers of specimens recorded from the different islands vary considerably, reflecting probably the extent of systematic collecting on the less visited islands rather than any scarcity of the insect on those islands.

Considerable modification in marking occurs in the forms from the various islands, mainly in the extent of the white areas; as these forms merge one into the other a taxonomic problem of some difficulty arises. I have examined 450 specimens in the British Museum (Nat. Hist.) from 27 islands, together with five types, and arrived at the following conclusions:

The type specimen described by Westwood is a female of unknown origin and represents the lightest form in the extent of the white areas. The next to be described was by van Vollenhoven, who illustrated a male as *anableps*, showing less white, but with the impossible locality "Otaheiti." Thus the type locality for neither of these names is known with certainty. Although light females occur on the southern islands and are not peculiar to one race, the males from Guadalcanal, St. Christoval, and Ugi Islands appear to be invariably of this form, and differ in this respect from *anableps* with its more extended dark marking. One is thus justified in associating the light male with the light female type, and calling both *phorcas*, leaving *anableps* for the darker race or form, in spite of the fact that Fruhstorfer regarded it as a synonym of *phorcas*.

While the question of *phorcas* is thus solved, there remains the difficulty of the relationship of *anableps* to the still darker form *atesta*. It will be seen from the distribution table that *anableps* appears associated with *phorcas* on many islands; when *phorcas* becomes rare in the north *anableps* is accompanied by *atesta* and continued by the extremely melanotic forms *farona* and *umbonia*.

There is difficulty in clearly separating these forms, which can be done only as they agree, more or less, with the recognized type. I regard *uranus* as a distinct race; its marking is more definite, and it appears to be almost confined to New Britain and New Hanover. In view of these facts I consider, tentatively, that the subspecies should be arranged thus:

Tenaris phorcas phorcas Westwood (1853). Genitalia, Pl. VI, fig. 4.
  f. *phorcas* Westwood (1853).
  f. *anableps* van Vollenhoven (1860).
  f. *atesta* Rebel (1895).
  f. *farona* Fruhstorfer (1912).
  ab. *bougainvilleana* Strand (1914).
  f. *umbonia* Fruhstorfer (1905).
Tenaris phorcas uranus Staudinger (1887).
Tenaris phorcas admiralitatis Rothschild (1916). Genitalia, Pl. VI, fig. 5.

The habitat and number of specimens will be found in the Distribution Table (p. 203).

The following short descriptions of the above forms give the features on which I have separated them.

The marking on the underside of the wings is not mentioned in the descriptions, as it follows to a corresponding extent that of the upperside, and is not clearly indicative.

T. phorcas f. *phorcas*.

♂. Fore wing: A well-defined white area at the anal angle, extending for about half the distance between the cell and the margin, terminating roundly anteriorly below vein 4.

Hind wing: The ocellus stands free in the white area widely separated from the brown marginal border. There is no brown ring, or only an indication, surrounding the ocellus. The female is similar.

T. phorcas f. *anableps*. ♂. Fore wing: Similar to *phorcas* but the upper segment of the white area between the veins is suffused with brown. Hind wing: The marginal border is wide, especially in the costal region, outwardly narrowing toward the ocellus to which it approaches, or to which it may be attached by a brown suffusion; the ocellus is nearly always surrounded by a distinct brown ring. The ♀ is similar.

T. phorcas f. *atesta*.—Differs from *anableps* only in the more extended dark marking.

T. phorcas f. *farona*.—Fruhstorfer in his description of this form appears to confuse it with *atesta*; he also states that his description is based on specimens from Fauro and Alu Islands in the British Museum (N.H.). These specimens exist, but as he left no record to indicate his type I have selected as the type the male from Fauro Island. The form is distinct from *atesta*, although near *umbonia*.

♂. Fore wing: The white spot of the previously described forms becomes light brown in *farona* or suffused with brown and completely surrounded by the dark brown ground colour. Hind wing: The border is wide at the costa and outwardly, terminating narrowly below the ocellus.

♀. Fore wing: The white area is reduced to an oval spot enclosed by the ground colour, and often traversed by the brown outline of veins 2 and 3. Hind wing: The brown marginal border surrounds the wing leaving a white area above the ocellus.

T. phorcas f. *umbonia*. ♂. Fore wing: Uniformly dark brown. Hind wing: The white area more restricted than in *farona*; the ocellus large with a prominent brown ring surrounding the yellow.

♀. Fore wing: There is only a slight indication of the light area. Hind wing: The white area is reduced to a somewhat irregular spot above the ocellus.

T. phorcas uranus. ♂. Fore wing: The white area is considerably reduced, also that on the hind wing, on which the border extends widely to the ocellus and almost includes it; these features are especially marked on the underside.

♀. Fore wing: The brown ground colour extends along outer margin to the tornus, and also along the inner margin, thus reducing the white area to a large oval spot. Hind wing: The brown margin completely surrounds the wing leaving only a small white area above the ocellus.

In the Distribution Table six females are recorded from Bougainville, under the f. *phorcas*. These very large insects do not differ in marking from the lightest form. The ab. *bougainvilleana*, of which the type in the Museum is the only known specimen, is exceptionally large with distinctive dark marking.

Tenaris phorcas. Distribution Table.

	ssp. phorcas.		*f. phorcas.*		*f. anableps.*		*f. atesta.*		*f. farona.*		*f. umbonia.*		*ssp. uranus.*		*ssp. admiralitatis.*	
	♂.	♀.	♂.	♀.	♂.	♀.	♂.	♀.	♂.	♀.	♂.	♀.	♂.	♀.	♂.	♀.
Guadalcanal	11	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rossel Is.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
St. Cristoval Is.	4	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ugi Is.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ulawa Is.	.	.	1	.	1	1	.	.	.	.	.	.	.	.	.	.
Rendova Is.	.	.	3	12	1	.	.	.	.	.	.	.	.	.	.	.
Florida Is.	.	.	.	.	8	3	.	.	.	.	.	.	.	.	.	.
Malaita Is.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Gizo Is.	.	.	.	2	9	1	.	.	.	.	.	.	.	.	.	.
New Georgia	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.
Ysabel Is.	.	.	.	1	1	3	.	.	.	.	.	.	.	.	.	.
Vella Lavella	.	.	4	6	1	2	.	.	.	.	.	.	.	.	.	.
Ranonga Is.	.	.	6	5	5	4	.	.	.	.	.	.	.	.	.	.
Treasury Is.	.	.	.	1	.	.	1	.	5	3	.	.	.	.	.	.
Shortland Is.	.	.	.	.	.	.	.	.	5	3	.	.	.	.	.	.
Alu Is. (nr. Shortland Is.)	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.
Choiseul Is.	.	.	.	.	6	2	8	6	.	.	.	.	.	.	.	.
Fauro Is.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
Bougainville (Harowa, Arowa)	.	.	4	6	2	3	.	.	11	17	.	.	1	.	.	.
Feni Is.	.	.	.	.	.	.	.	1	.	.	9	8	.	.	.	.
Duke of York Is. (N. Lauenberg)	.	.	.	.	1	.	1	1	.	.	.	.	.	4	.	.
New Britain (N. Pomerania)	.	.	.	.	.	.	.	.	.	.	.	.	22	37	.	.
New Ireland (N. Mecklenberg)	.	.	1	1	36	11	5	10	6	4	.	.	2	.	.	.
Rook Is.	.	.	.	.	.	.	.	.	.	.	.	.	10	5	.	.
Witu Is.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	.	.
New Hanover	.	.	.	.	.	.	5	12	4	2	13	6	15	11	.	.
Admiralty Is.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14	13

3. *Tenaris scylla* Staudinger, 1887.

Tenaris scylla Staudinger (1887).

Syn. *Tenaris dohertyi* H. G. Smith (1894).

Habitat : Schouten Islands, Koreido, 5 ♂; Biak, 9 ♂, 3 ♀; Bosnik, 1 ♂, 4 ♀.

4. *Tenaris macrops* C. & R. Felder, 1860.

Tenaris macrops macrops Felder (1860). Genitalia, Pl. VI, fig. 6.

Habitat : Halmahera, Batjan and Morotai. Specimens from Halmahera are less numerous than those from Batjan where it appears to be a very common insect. The female f. *psola* Brooks (1944) occurring at Patani, S.E. Halmahera, has the fore wing as dark as the male. Ocellar variation is fairly frequent.

Tenaris macrops ternatana Fruhstorfer (1909).

Habitat : Ternate, 10 ♂, 11 ♀. The dark form *psola* occurs among them.

Tenaris macrops macropina Fruhstorfer (1904).

Habitat : Obi Island, where it appears to be common. The ♀ f. *psola* is fairly numerous. Among the females a very unusual aberration occurs ; the upperside is normal, on the underside of the fore wing the dark borders are reduced in width, on the hind wing underside the normal broad border below the costa is absent and the space is filled with very light cream colour, the small dark area at the base remains, and the other dark markings are less and reduced in width ; the ocellus is large and an extra ocellus (ab. *opulenta* Stichel) is included in the wide yellow surround.

In many cases it is difficult to distinguish the subspecies of *macrops* from one another, but sufficient consistent variation exists in the series to justify regarding them as subspecies.

Among the Museum specimens there are several from unrecorded localities, which is not an unusual occurrence. The number of such specimens of *macrops* is exceptionally large, and for this reason it appears to be worth recording them in the hope of obtaining confirmation from other sources. These specimens represent all the races ; if their localities are correct the species appears to be a wanderer. The list is as follows :

Locality.	♂.	♀.	Collector or origin.
Ceram	.	1	Ex Coll. Crowley.
Ambon	2	2	Forbes.
N. Guinea	2	1	Ex. Coll. Crowley.
Waigeu	1	.	Wallace.
Arou	1	.	Ex Coll. Boisduval.
Kaioa Is. (Kei ?)	1	1	Wallace.
Tenimber Is.	7	3	Frost.

Tenimber is improbable ; in several cases Frost's specimens are labelled incorrectly. Single specimens of *macrops* from Borneo and Celebes are recorded by Pagenstecher (1897, *Abh. Senckenb. Naturf. Ges.* **23** : 415).

(*Tenaris macrops sura* Brooks, see *T. selene.*)

5. *Tenaris selene* Westwood, 1851.

Genitalia, Pl. VI, fig. 7. Specialized scales, Pl. III, fig. 4.

Tenaris selene selene Westwood (1851).

Habitat: Buru, 16 ♂, 26 ♀.

Tenaris selene gigas Staudinger (1887).

Habitat: Ceram, 27 ♂, 19 ♀.

Both the males and females are more variable than those from Buru; two distinct forms have been described, of which f. *pseudomacrops* Rothschild (1915) represents the very light male form of *selene* from Buru. The female associated with this form by Rothschild appears to be one of the forms of ♀ f. *tetrica*. There is no specimen labelled as "Type."

Tenaris selene ♀ f. *tetrica* Stichel (1906).

This form has the fore wing nearly filled with greyish-brown, but the distinction is not sharp as the specimens grade from greyish-brown (*tetrica*) to dirty white. In *Tenaris macrops* this form is paralleled by *psola* Brooks.

Tenaris selene sura Brooks.

Syn. *Tenaris macrops sura* Brooks (1944).

Habitat: Geisser Is., 1 ♂, 1 ♀ (types).

On re-examining the types I consider this insect should be placed under *selene*; its small size and similar marking led to the confusion in mistaking it for *macrops*.

Tenaris selene is so close to *macrops* that were it not for the anal ocellus being more distant from the margin than in *macrops* they would be considered as one species.

6. *Tenaris bioculatus* Guérin-Méneville (1830).

Genitalia, Pl. VI, figs. 8, 9, 10. Specialized scales, Pl. III, fig. 5.

Tenaris bioculatus is a very distinct species. The neuration of the fore wing differs from that of all other species of *Tenaris*: Vein 5 springs from the discocellular near 4 with a long interval between 5 and 6, the latter being near 7, and the cell is long and narrow. On this variation Boisduval established the genus *Hyades*, as pointed out by Talbot (1915, *Proc. ent. Soc. Lond.* **1915**: liv). Also the ocelli have blue internal rings replacing the yellow of the other species. Although these differences exist, the genitalia and other features point to *Tenaris*, and to re-establish the genus *Hyades* is uncalled for.

The species has been taken throughout the mainland of New Guinea, but it occurs on only two of the western islands, where it is common; it is unknown from the islands in the east. It is of interest to note the sharply defined zones in which colour changes occur, and that in these zones, which extend over large areas, there is marked uniformity of wing pattern, especially on the underside. On the islands and western peninsula insects having a light buff ground colour with brownish markings appear, extending their range south of Geelvink Bay to the Aroa River and somewhat inland, where they suddenly end; among them dusky and lighter forms appear. On the north side of the island from Geelvink Bay, the ground colour changes to nearly white with greyish-black marking, to the east beyond Finchafen they are pure white with intensely black marking filling the upperside of the hind wing. Considering the large area over which the species extends there are few subspecies and little tendency to local forms.

Tenaris bioculatus bioculatus Guérin-Méneville (1830). Genitalia, Pl. VI, figs 9 and 10.

Syn. *Hyades indra* Boisduval (1832) ; *Tenaris bioculatus pallida* Fruhstorfer (1905).

Habitat : Waigeu, 16 ♂, 20 ♀; Gebi Is., 10 ♂, 1 ♀; Salawatti, 1♂, 4♀; Sorrong, 1 ♂, 2 ♀; Ati Ati Onin, 1 ♀; Dorey, 8 ♂, 5 ♀; Wandesi, 2 ♂; Coast near Arfak, 1 ♀; Mun Is., 1 ♀; Mankwari, 1 ♀; Momi Riv., 2 ♀; Kapur, 14 ♂, 13 ♀; Fak Fak, 2 ♀; McClure Gulf, 3 ♂, 3 ♀; Coast Dist. Geelvink Bay, 1 ♂, 2 ♀; Mioswar Is., 3 ♂, 1 ♀; Wandamman Mts., 2–3000 ft., 1 ♂, 2 ♀; Wangaar Riv., 8 ♂, 2 ♀; Wangaar, 4 ♂, 1 ♀; Nomnagihai, 6 ♂, 1 ♀; Kajumera Bay, 1 ♂; Dutch N. Guinea, 2 ♂, 2 ♀.

I can discover no feature to distinguish the insects occurring on these islands from each other, nor does the mainland form described by Fruhstorfer as subsp. *pallida* differ in any way.

There is some variation among these specimens, the light buff ground colour becoming almost white at times.

Tenaris bioculatus **albius** subsp. n.

The black subapical area of the fore wing does not extend outwardly much beyond vein 3; the white area is more clearly defined and the dark-marking more intense than in ssp. *bioculatus*. It appears to be a mountain race distinct from ssp. *bioculatus*. One of the males from Arfak is larger and more dusky than the remainder and is probably an individual form.

Habitat : Mt. Siwi, Arfak, 2600 ft., 5 ♂, 1 ♀; Mt. Kunupi, Menoo Valley, Weyland Mts., 6000 ft., 1 ♂, 1 ♀; Wai San Riv., 1000 ft., 1 ♂.

Tenaris bioculatus subsp. ?

There is too little material to permit of a decision as to the status of these specimens, of which one resembles *pallida* while the other favours *charonides*.

Habitat : Jobi Is., 2 ♀.

Tenaris bioculatus grisescens Rothschild (1915).

Habitat : Nr. Otakwa Riv., Snow Mts., 3500 ft., 4 ♂, 2 ♀; Base Camp, Utakwa Riv., Sea level, 2 ♂, 1 ♀; Up. Setakwa Riv., Snow Mts., 4 ♂, 2 ♀; Eilanden Riv., 1 ♂. There are 2 ♂ labelled Australia, Kuranda, Queensland, a very doubtful locality. Although slightly different from *grisescens* they appear to belong to this race.

Tenaris bioculatus avarea Fruhstorfer (1915).

Habitat : S.W. Dutch New Guinea.

Not represented in the Museum.

Tenaris bioculatus charondas Fruhstorfer (1911).

Habitat: Lower Aroa Riv., 4 ♂, 3 ♀; Dinawa, 1 ♂; Kikori Riv., foothills, 1 ♂.

Tenaris bioculatus cameronensis Rothschild (1916).

Habitat: Owen Stanley Range, 1 ♂, the type.

Tenaris bioculatus charonides Staudinger (1894).

Habitat: Humboldt Bay, 14 ♂, 9 ♀; Eitape, 1 ♂, 1 ♀; Fr. Will. Hafen, 2 ♂, 4 ♀; Erina, 4 ♂, 3 ♀; Stephensort, 5 ♂, 4 ♀; Astrolabe Bay, 9 ♂, 8 ♀; Constantinhafen, 3 ♂, 4 ♀; Finchafen, 1 ♂, 1 ♀; German N. Guinea, 12 ♂, 23 ♀; Finisterre, 1 ♂.

Tenaris bioculatus charon Staudinger (1887). Genitalia, Pl. VI, fig. 8.

Habitat: Finchafen, 1 ♀; Sattelberg, 3 ♂, 3 ♀; Berg Gehr, 3 ♂, 1 ♀; Lower Membare Riv., 1 ♂, 1 ♀; Baigi Mambare, 5000 ft., 4 ♂; Kumusi Riv., 8 ♂, 9 ♀; Hydrographer Mts., 2500 ft., 12 ♂, 5 ♀; Moroka, 1 ♂; Mt. Alexander, 1 ♂; Collingwood Bay, 1 ♂; Samarai, 1 ♀; Milne Bay, 11 ♂, 7 ♀; Port Moresby, 2 ♂, 2 ♀; British N. Guinea, 2 ♂, 2 ♀.

7. *Tenaris gorgo* Kirsch, 1877.

Genitalia, Pl. VI, figs. 11, 12, 13. Specialized scales, Pl. III, fig. 7.

There are very few species of *Tenaris* in which the anal ocellus, on the upperside of normal specimens, is absent; the most conspicuous is *gorgo*, and for this reason it is worthy of special mention. However, among the Museum's 72 males and 68 females, five of the former show a very small ocellus, complete with yellow and brown rings, and one female has just a dark spot; these belong to ssp. *gorgophone* from Mandated Territory, which district is notorious throughout the genus for the ocellar variations that occur there. A further interesting feature is the delicate feathering on the subcostal of the fore wing, extending from the base to the junction of vein 7. This very distinctive character is also present to a slight extent in *Tenaris bioculatus*.

The various races occur on a few islands in the west and the mainland, excepting the extreme eastern British N. Guinea. Over this area there is little variation on the upperside, but on the underside, in the Mandated Territory, the usual darkening appears, and ocellar complications occur; the anal ocellus may be simple or duplicated in the same race.

Tenaris gorgo gorgo Kirsch (1877). Genitalia, Pl. VI, figs. 11, 12, 13.

Habitat: Sorong, 4 ♂, 3 ♀; Dutch N. Guinea, 2 ♂, 2 ♀.

Tenaris gorgo subsp. ?

Habitat: Salawatti, 1 ♂, 1 ♀.

Both sexes differ from *gorgo*, but, as the difference is not considerable, I hesitate to describe them as a new race until confirmed by further specimens.

Tenaris gorgo danalis Fruhstorfer (1904).

Habitat: Waigeu, 9 ♂, 3 ♀.

The anal ocelli are variable; five specimens have a small single ocellus; in two males and one female they are large with the second small black ocellus within the yellow ring; two males have double ocelli.

Tenaris gorgo mera Fruhstorfer (1905).

Habitat: Arfak, Momi Coast, 1 ♂, 1 ♀; Momi, Arfak Mts., 4000 ft., 1 ♂; Wangaar, 1 ♂, 1 ♀; Wangaar Riv., 600 ft., 9 ♂; Kapur, 1 ♀; Nomnagihe, 25 miles S. of Wangaar, 600 ft., 2 ♂; Djalan Riv., S. Geelvink Bay, 1 ♂; Kadjmera Bay, 1 ♀ (type).

Although slight differences occur I do not think the specimens from the north and south are separable. The type of *mera* is a female, which has been described as a form; however, it is a good race of which I now describe the male, selecting as the neoallotype a specimen from Wangaar.

♂ Upperside, both wings similar to *gorgo*. Underside, fore wing: The dark area below the apex more extended outwardly than in *gorgo*. Hind wing: The very dark costal border as wide as the ocellus, which it encloses, extending broadly on the outer margin to enclose the anal ocellus, beyond which it becomes narrow on the anal margin, to the base on the anal and costal margin, internally sharply defined, whereas the other portion of the border is suffused with white for nearly half the width of the wing; below the base a strong yellow area. The ocelli rather large with a very distinct blue suffusion.

Tenaris gorgo mera ♀ f. *arfakia* Strand (1917).

Presumably this is an aberrant female of the above race.

Tenaris gorgo lucina Brooks (1944).

This race was described from a female; the male is now described as follows:

Upperside, both wings slightly lighter than *mera*. Hind wing, underside: The broad band on the costa extends narrowly around the wing to the base. The outer border strongly suffused inwardly to fill half the wing, an orange area below the base. The anal ocellus small without blue suffusion; this at once separates this race from *mera*.

Habitat: Oetakwa Riv., near Snow Mts., 3500 ft., 1 ♂, 2 ♀, including the types; Upper Setakwa Riv., Snow Mts., 2–3000 ft., 2 ♂; Eilanden Riv., 2 ♂, 1 ♀.

Tenaris gorgo yulei Bakker (1942).

Syn. *Tenaris gorgo thyia* Brooks (1944).

Habitat: Aroa Riv., 2 ♀.

Tenaris gorgo gorgophone Fruhstorfer (1904).

Habitat: Humboldt Bay, 3 ♂, 2 ♀; Entape Dist., 1 ♂; Fr. Will. Hafen, 7 ♂, 5 ♀; Erima, 2 ♀; Stephensort, 7 ♂, 6 ♀; Constantinhafen, 3 ♂, 5 ♀; Astrolabe Bay, 8 ♂, 13 ♀; Finchafen, 1 ♂, 1 ♀; Mandated Territory, locality unspecified, 16 ♂, 15 ♀.

Tenaris gorgo **gorgias** subsp. n.

♂. Fore wing, upper and underside: As *gorgophone*. Hind wing: as *gorgophone* but a decided black replacing the grey. Underside: A broad dark border on the costa, continued narrowly around the wing to the base; between the ocelli and to the tornus the band is suffused or speckled, inwardly, extending so as nearly to fill the space between the ocelli with their brown outer rings. The ocelli are large, that in the anal area always double in both sexes; the white centres are surrounded by a zone of blue suffusion, the dark outer ring suffuses into and intrudes on the yellow ring, especially on the inner side where the yellow may be eliminated.

♀. Both wings upperside as the male, but darker. Hind wing underside differs from *gorgophone* in the deeper black marking, and more widely suffused area on the outer portion of the wing; the double ocelli as in the male. The white areas in both sexes are purer than in *gorgophone*.

Habitat: Rawlinson Mts., 1 ♂, 1 ♀ (types); Sattelberg, 200 ft., 1 ♂; Markham Riv., Huron Gulf, 1 ♀; locality unknown, 2 ♀.

8. *Tenaris dina* Staudinger, 1894.

Genitalia, Pl. VI, fig. 14. Specialized scales, Pl. III, fig. 6.

Tenaris dina, although occurring over a large area, is one of the rarest species, and it is also unusual in that the females are more plentiful than the males. The remarkable form of the gnathos and clasp, which differ from all other species of *Tenaris*, suggests that it belongs to a distinct genus. For this reason a dissection of the female sex organ was compared with one of *urania*, but no essential difference was disclosed. The venation and general appearance which are as in *Tenaris*, confirm its retention in the genus.

Tenaris dina insularis Rothschild (1916).

Habitat: Sorong, 1 ♂, 1 ♀; Salawatti, 1 ♂ (type); N. Guinea, 2 ♂, collected by L. Laglaize.

Tenaris dina subsp. ?

Habitat: Nomnagihe, 25 miles south of Wangaar, at 2000 ft., 1 ♂; Wangaar Riv., 15 miles from the coast, 600 ft., 1 ♀.

These are not quite in agreement with *insularis*, or the female with *sordidior*; further material is required to confirm a new race.

Tenaris dina sordidior Rothschild (1916).

Habitat: Near Oetakwa Riv., Snow Mts., 3500 ft., 1 ♀ (type).

Tenaris dina dina Staudinger (1894).

Habitat: Stephensort, 1 ♂; Constantinhafen, 2 ♂, 4 ♀; Astrolabe Bay, 1 ♀; Fr. Will. Hafen, 2 ♀; German N. Guinea, 8 ♀.

9. *Tenaris domitilla* Hewitson, 1861.

Genitalia, Pl. VI, fig. 15. Specialized scales, Pl. III, fig. 8.

T. domitilla is a species having double anal ocelli on the hind wing showing above and below. This is a persistent feature, and in no normally veined specimen is it absent, but the apical ocellus on the underside may not show above, as in ab. *duplex* Stichel. A small third ocellus often appears in interspace 4, enclosed in the yellow surround with the lower two (ab. *prodiga* Fruhstorfer); the third ocellus rarely shows above and then only in *agrippa*.

Fruhstorfer in his arrangement of the species of *Tenaris* places *domitilla* directly before *butleri* and also suggests that *butleri* replaces *domitilla* in the Papuan district. I cannot agree with this, as the species are dissimilar and widely separate in their characteristics; for instance, the anal ocelli in *butleri* occur in the interspaces 1*c* and 2, in *domitilla* in interspaces 2 and 3, also the male sex armature is totally different.

Tenaris domitilla domitilla Hewitson (1861).

Habitat: Batjan, a fairly common insect. A male captured by Wallace is recorded from Celebes.

Tenaris domitilla diops Snellen van Vollenhoven (1863).

Habitat: Halmahera. This insect appears to be fairly common. There is little to distinguish it from *domitilla*.

Tenaris domitilla agrippa Fruhstorfer (1903).

Habitat: Obi. A very common and distinct race. Specimens are recorded from the following places: Latu, Pulo, Bisa and Laiwui.

10. *Tenaris onolaus* Kirsch (1877).

Genitalia, Pl. VI, figs. 16, 19, 20.

This is a well-defined species, undoubtedly, and Lord Rothschild correctly separated it from *honrathi*, with which species it had previously been included; the subspecies of both are easily distinguished one from the other.

In extension of my remarks on *Tenaris onolaus* (Brooks, 1944, *Proc. R. ent. Soc. Lond.* (B) **13**: 109) I have decided that the series of fairly uniform specimens originating from the country to the west of Geelvink Bay between Arfak in the north and Wangaar in the south, must be accepted as *onolaus onolaus* Kirsch. The type came from Geelvink Bay; Rubi, one of the places mentioned in the original description, is near Wangaar; although these specimens are not in good agreement with the figured type (Kirsch, 1877, *Mitt. Zool. Mus. Dresden* **2**: 122, t. 6, f. 7), which has a narrow border on the hind wing, resembling that of *saturatior* from British New Guinea which is mentioned by Fruhstorfer (*Seitz. macrolep.* **9**: 420), in other respects they agree. It must be remembered that the drawing may not be entirely reliable or possibly the type is exceptional. Generally this border is distinctive of the race.

Tenaris onolaus onolaus Kirsch (1877). Genitalia, Pl. VI, fig. 16.

Habitat: Momi Coast, Arfak, 12 ♂; Momi River, 4 ♂, 4 ♀; Ninay Valley, 3 ♂; Angi Lakes, 6000 ft., 4 ♂; Siwi Mt., 1 ♀; Momi, 4000 ft., 1 ♂; Passin Island, 1 ♀; Mioswar Island, 1 ♁; Kwatizone, 9 ♂, 1 ♀; Wangaar, 2 ♂, 4 ♀; Djalan Riv., 1 ♂; Triton Bay, 1 ♀.

Tenaris onolaus shapur Brooks (1944). Genitalia, Pl. VI, fig. 19.

Habitat : Wandamman Mountains, 3–4000 ft., 4 ♂, 2 ♀; Weyland Mountains, 1–6000 ft., 4 ♂, 7 ♀ (including the types).

I described *shapur* as a form of *onolaus*, but after further consideration I think that it should be accorded subspecific rank ; it represents a mountain race.

Tenaris onolaus ida Honrath (1889). Genitalia, Pl. VI, fig. 20.

Habitat : Finschafen, 5 ♂, 1 ♀; Simbang, 4 ♂, 3 ♀; Rawlinson Mts., 3 ♂, 1 ♀; Bulolo River, 1 ♂; Saddelberg, 1 ♂; Mandated Territory. 3 ♂, 4 ♀.

Tenaris onolaus saturatior Fruhstorfer (1904).

Habitat : Mt. Cameron, 9 ♂, 4 ♀; Meroka to Mt. Nisbet, 1 ♂, 1 ♀; Welsch Riv., 2 ♂; Brown Riv., 2 ♂; Redscar Bay, 3 ♂; Lower Aroa Riv., 8 ♂, 3 ♀; Aroa Riv., 7 ♂; Port Moresby, 4 ♂, 6 ♀; Dinama, 4000 ft., 3 ♂; Ekeikei, 1500 ft., 8 ♂, 5 ♀; Epa, 1 ♂, 2 ♀, also the types.

The typical form has almost dead black fore wings, but specimens having a very dark brownish grey occur at high altitudes.

Tenaris onolaus montana Stichel (1906).

I have withdrawn this insect from *onolaus*, considering it to be a distinct species, placing it to follow *honrathi*, where my reason for doing so is fully discussed.

11. *Tenaris honrathi* Staudinger (1886).

Genitalia, Pl. VI, fig. 18. Specialized scales, Pl. III, fig. 9.

There is little to distinguish the males of *honrathi* from those of *hyperbolus* and *dioptrica*, also their distribution is similar, except that *honrathi* has a more easterly extension where it is a common insect ; however, the male of *honrathi* may be separated from the two other species by the absent or only slightly indicated hair-streak on the submedian fold of the hind wing. Also the darkish scale patch on the anal margin has a suffused boundary as in *hyperbolus*, but differing from *dioptrica*, which has a well-defined boundary. The fore wing of the female is generally uniformly coloured without the light or white area below the apex which occurs in the other two species. The separation from *onolaus* has been mentioned under that species.

Tenaris honrathi honrathi Staudinger (1886).

Habitat : Waigeu, 22 ♂, 21 ♀; Gebi Island, 2 ♂.

The males from Gebi do not differ from those of Waigeu. The dominant female form is f. *abdon* Fruhstorfer (1911) ; only three specimens in the series have the discal area of the hind wing white ; no male is abnormally dark.

Tenaris honrathi sekarensis Staudinger (1887).

Habitat : Sekar, 1 ♂, the type ; Sorong, 1 ♂, 2 ♀.

Tenaris honrathi **ladas** subsp. n.

♂. Upperside, both wings as *ritsemae*; underside, the dark border of the hind wing is much wider, especially that on the costa. ♀, like the male, but larger.

Habitat: Oetakwa Riv., 3500 ft., 1 ♂ (type); Eilanden Riv., 1 ♀ (type). Others from Base Camp, Oetakwa Riv., 2 ♂; Upper Oetakwa, 4 ♂, 1 ♀; Eilanden Riv., 5 ♂, 4 ♀.

There is some variation among these specimens, especially in the size of the ocellus; as their genitalia are similar, and distinct from those of *ritsemae*, there is no reason to regard them as separate forms.

Tenaris honrathi ritsemae Fruhstorfer (1904). Genitalia, Pl. VI, fig. 18.

This is the only race plentiful on the mainland. Its range extends from Humboldt Bay, Mandated Territory, and in the south, to British New Guinea, where it is rare. Fruhstorfer has distinguished the race from Mandated Territory as *rebeli* (1904). His type, which is in the Museum, is a light form which also occurs among the specimens from Humboldt Bay. Although *rebeli* occurs more frequently in the east I do not think it is separable from *ritsemae* as a good subspecies and I regard it as a form. Specimens showing ocellar aberration are very numerous; these are rare in the west, but very common in insects from the east. Among the females there are specimens with dark brown marking, also others with the fore wing internally lighter as far as the inner margin. The form *auriflua* Fruhstorfer (1905) (=*orientalis* Rothschild, 1916, see p. 219) has the yellow ring of the anal ocellus on the underside expanded irregularly on one side towards the tornus; this frequently occurs, and a second ocellus often appears in the extended yellow space (*opulenta* Stichel). These numerous ocellar variations include most of the named aberrations, and several of them often occur on one insect; thus we find *duplex*, *sidus* and *opulenta* appearing together, which demonstrates the difficulty or futility of these names.

Habitat: Humboldt Bay and the coast to Geelvink Bay, 56 ♂, 15 ♀; Cyclops Mts., 2 ♂; Fred. Will. Hafen, 8 ♂, 11 ♀; Bongo, 3 ♂; Stephensort, 4 ♂, 7 ♀; Constantinhafen, 4 ♂, 7 ♀; Finchafen, 1 ♂; Astrolabe Bay, 7 ♂, 9 ♀; Erina, 15 ♂, 9 ♀; Mandated Territory, 6 ♂, 11 ♀.

Tenaris honrathi enomia Fruhstorfer (1904).

The ♂ type from Collingwood Bay is in the Museum with two other males from near Mount Albert Edward. It appears to be a distinct race.

In the Museum collection there are also 2 ♂, 1 ♀ from Letti Island (Forbes) which somewhat resemble *enomia*, but as they do not agree with each other they remain undescribed; 1 ♂, Kwatizore, S. Geelvink Bay, has a brown, almost black fore wing; the underside of the hind wing has a narrow outer border, giving a large white central area. I hesitate to name this single specimen.

12. *Tenaris montana* Stichel (1906).

Pls. v, *va*, figs. 3 and 4. Genitalia, Pl. VI, fig. 17.

Tenaris montana montana Stichel (1906).

Syn. *Tenaris mailua dionus* Brooks (1944).

Previously this species has been accepted as a race of *Tenaris onolaus* and placed with *saturatior* as a second subspecies occurring in British Territory.

Dissection of the male genitalia shows that it is distinct from *saturatior*, chiefly in the form of the clasp ; the submedian fold of the hind wing carries a hair-streak which is absent in the races of *onolaus* ; further, its small size and the grey-brown colour of the fore wing are distinctive. The two races fly together and the Museum series show that from each locality where *montana* has been taken *saturatior* is represented by both sexes, since the long series of *montana* are all males, and there does not appear to be a female among those of *saturatior* which can be allocated to *montana* it seemed possible that the female might be a differently marked insect. I described *dionus* from Ekeikei, having no corresponding male (Brooks, 1944), and placed it as a subspecies of *mailua* with which the fore wing is in some agreement. The yellow area of the hind wing, however, is foreign to *mailua*, but is in exact agreement with that of *montana*, as are the size and grey-brown colour ; for these reasons I have no hesitation in accepting *dionus* as the female of *montana*. The dimorphism of the sexes is paralleled by *hyperbolus* and *dioptrica*, and as the male sex armature favours these species I have placed it to follow *honrathi* and before *hyperbolus*.

Habitat : Epa, 4 ♂, including the type ; Kebea, 2 ♂ ; Dinawa, 2 ♂ ; Ekeikei 7 ♂, 3 ♀ ; Upper and Lower Aroa River, 4 ♂ ; Port Moresby, 2 ♂ ; British N. Guinea, 1 ♂, 2 ♀ ; Kapur, 1 ♂ (probably this label is in error, as the locality is most unlikely).

13. *Tenaris hyperbolus* Kirsch (1877).

Pls. V, V*a*, figs. 5, 6. Genitalia, Pl. VI, fig. 21.

Tenaris hyperbolus is a little known insect very similar to *dioptrica*, with which it has been confused ; there is also a similarity with *honrathi*, the distinction from which has already received mention under that species.

The hairs on the gland below the costa of the hind wing are light, whereas in *dioptrica* they are dark. The chief feature distinguishing *hyperbolus*, at sight, is that the scales under the hair-streak on the abdominal margin instead of being black are brown and suffuse into the white ; in some cases the boundary may be somewhat obscure, but generally the separation is easily effected. By means of this character 68 males have been allocated to *hyperbolus*.

The male sex armature is generally similar to that of *dioptrica* but distinguished by the form of the wing of the clasp ; in *dioptrica* the wing is narrow and somewhat concave from the shoulder to the base, in *hyperbolus* the concave margin extends for only a short distance below the shoulder, then expands to a convex projection or step.

As far as I can ascertain only one female of *hyperbolus* has been recorded, under the name *concolor* Hulstaert (1925), and was not assigned to any described male. With so large a number of males in long series from various localities it seemed curious that no female had been directly associated with them. Since the males of *hyperbolus* and *dioptrica* are so similar in wing pattern, it seemed probable that the females were also similar, and on going through the females of *dioptrica* from localities corresponding to those of *hyperbolus* I found specimens showing a constant variation from the typical *dioptrica*, and I have accepted them as females of *hyperbolus*. Moreover, dissection of the sex organ showed a distinct difference between them. They are few in number and receive mention under the review of the subspecies.

There is also a female in the collection which probably belongs to *hyperbolus*, but it differs from the above-mentioned females, and is not conformable to any male in the collection, though the markings indicate this species rather than any other. It comes from Central New Guinea, a district from which no males are recorded ; provisionally I have accepted it as a form of *hyperbolus* and described it under the name *oenone*.

It is obvious that *hyperbolus* is not so rare as the records lead one to suppose, it appears chiefly in the West and closely follows the distribution of *dioptrica*. In some districts it appears to be fairly plentiful. There is a specimen labelled Ambon and another Ternate, but as these localities appear extremely unlikely and the specimens are not markedly different from named races further comment is uncalled for.

Tenaris hyperbolus **hyginus** subsp. n.

♂. Fore wing upperside : Rather darker than in *hyperbolus*, with only a slight indication of white on the inner-margin. Hind wing upperside : From vein 3 to the costa and on the outer margin greyish-brown, darker outwardly, much darker below the ocellus from which it continues as a border to the base. A fair-sized ocellus with a white pupil and yellow ring. Underside : like *hyperbolus*.

Habitat : Waigeu, 7 ♂, including the type.

This insect so closely resembles *honrathi* from Waigeu that I was puzzled in deciding that it belonged to another species ; although the scales under the anal hair streak are very similar and cannot be considered distinctive, the determining indications are as follows : Nearly all specimens of *honrathi* have on the underside anal ocellus some expansion of the yellow ring at the tornus which in the majority covers a considerable area ; in *hyginus* the yellow and brown rings are complete and surrounded on the anal side by the black border ; also, as in *hyperbolus*, there is on the submedian fold the long hair-streak, white near the base, and changing to yellow-brown as it extends, absent in *honrathi*. The male sex armature is different.

In the long series of females of *dioptrica amitaba* from Waigeu there were three specimens which agree with each other and differ from the remainder. These I assume represent ♀ *hyginus*. The white area on the fore wing is smaller and somewhat dingy, the hind wing is filled with a warmish brown, in contrast to the grey-brown of *dioptrica*, which is broadly dark outwardly becoming lighter toward the base. A large anal ocellus surrounded by a prominent yellow ring. The underside like *dioptrica*.

Tenaris hyperbolus **hyaeus** subsp. n.

♂. Fore wing upperside : Greyish-brown, slightly darker than *hyperbolus*, a yellow streak on the costa, on the inner margin a prominent white border across the wing. Underside : Deep greyish black, a small white area beyond the cell, and the inner margin lighter. Hind wing upperside : The costal margin nearly white, at the apex a greyish border as broad as the ocellus on the underside, extending outwardly, narrowing toward the tornus then continued as an edging to the base, internally pure white. A small black ocellus with yellow surround. Underside : The dark grey-black border which surrounds the wing is narrower than on *hyperbolus*.

Type from Nomnagihe, 25 miles south of Wangaar, at 2000 ft. (C. F. and J. Pratt, ex Joicey Coll.).

The specimens vary in the series from the different localities. While the dark form is the most numerous, somewhat lighter examples occur together with other minor variations; although these differences occur over a large area there seems to be no reason to consider them as other than one race.

Habitat: All males, 5 Arfak, 1 Dorey, 1 Wandesi, 2 Ninay Valley, 2 Kapur, 6 Fak Fak, 1 McClure Gulf, 9 Wangaar, S. Geelvink Bay.

I have not been able to associate any females.

Tenaris hyperbolus versteegi v. Eecke (1915). Pl. V and V*a*, figs. 5, 6.

The original description of this insect is not very clear, but through the kindness of Dr. G. Kruseman of Amsterdam, who permitted me to compare the type with the specimens in London, I have been able to confirm the determination of 14 ♂, 2 ♀, Upper Setakwa Riv., Snow Mts., 2–3000 ft.; 4 ♂ near Oetakwa Riv., Snow Mountains, 3500 ft., and 2 ♂ Eilanden River.

This insect is slightly larger than *hyperbolus*, on the hind wing underside the marginal border is wide to include the ocelli; thus the white internal area is smaller than in *hyperbolus*, as are also the ocelli. One of the Amsterdam specimens has on the upperside hind wing a large ocellus with a wide yellow ring, and two specimens have additional ocelli on the underside. Two females from the Upper Setakwa River which I refer to *versteegi* have the submedian area filled with light yellowish hairs. *T. dioptrica rileyi*, which also flies in the same district, has the hairs in the submedian area white. Hitherto these females have been confused.

Tenaris hyperbolus **hyllus** subsp. n.

♂. Fore wing upper and underside as in *hyperbolus*. Hind wing upperside: Costal and outer margins broadly greyish-brown, darker outwardly, narrower at the anal angle and continued narrowly to the base; internally suffusing to a dirty white area in the disc. Underside: The wide dark marginal border which completely surrounds the wing, including the ocelli, is suffused internally to the small white discal area. Ocelli small.

1 ♂. Type. The foothills between the Kikori and Purari Rivers, British New Guinea.

Tenaris hyperbolus hyperbolus Kirsch, 1877. Genitalia, Pl. IV, fig. 21.

The specimens are very uniform, and none shows an ocellus on the upperside (f. *automolus*). 14 ♂ Ansus, Jobi Island; 1 ♂, Mioswar Island; 1 ♂ from Sorong Hatam differs from the Jobi specimens in having the hind wing filled internally with yellowish white.

Tenaris hyperbolus hyperbolus f. *automolus* Kirsch, 1877.

This differs from *hyperbolus* only in having a small ocellus on the upperside. 1 ♂, Salawatti.

I can find no female referable to this form.

Tenaris hyperbolus hyperbolus ab. *macropthalmus* Fruhstorfer, 1905.

Syn. *Tenaris honrathi macrophthalmus* Fruhstorfer.

Habitat: Jobi Island. 1 ♂ (type).

This insect has all the features characteristic of *hyperbolus*; it only differs from the Jobi Island specimens in that the ocelli on the underside with their yellow rings are very large. Although *hyperbolus* varies considerably in the size of the ocelli, none has them so large as in this specimen, yet I do not consider that this single feature justifies regarding *macrophthalmus* as a race, and it is certain that the position assigned to it by Fruhstorfer as a race of *honrathi* is untenable.

Tenaris hyperbolus **oenone** subsp. n.

♀. Fore wing upperside: Greyish-brown as in *hyperbolus*, a small white area below the apex with suffused edging, not extending to the costa and outer margin nor entering the cell. Underside: As above, but the light area smaller and less defined. Hind wing upperside: Broad greyish-brown covering one third of the wing outwardly and to the tornus, internally greyish white, densely covered with yellowish-brown hairs from the base in the submedian area. A small brown ocellus. Underside: A brown border on the costa, narrowing toward the ocellus, outwardly as wide as the apex as the ocellus, narrowing toward the anal ocellus and continuing below, and extending widely to the base, suffused internally to brownish-white. Ocelli large with prominent yellow and brown rings.

1 ♀. Central New Guinea.

In addition to the foregoing there are four specimens of uncertain origin which differ slightly from described forms; these I have left until confirmed by further material.

14. *Tenaris dioptrica* Snellen v. Vollenhoven (1860).

Genitalia, Pl. VI, fig. 22.

This species occupies a somewhat ambiguous position; its relationship to *mycops*, especially ssp. *rothschildi*, is shown by the genitalia, and the marking of some of the forms is very similar; this is also the case with *hyperbolus*. As I have already pointed out, *hyperbolus* and *dioptrica* are often found confused in collections, but the separation from *hyperbolus* is at once obvious by the form of the dark coloured scale patch under the hair-streak by the anal margin; in *dioptrica* and *rothschildi* the boundary of this patch is always abrupt and well defined.

The habitat is almost completely restricted to a few islands west of New Guinea and the western peninsula, extending to the south of Geelvink Bay and the coastal region to Digul; one race is recorded from Humboldt Bay. Over this area the species in its general form of marking undergoes little change, but there is individual variation; the island races from Waigeu and Gebi are more constant.

Some of the types of described forms represent the extremes of variation, so that in the determination of specimens a somewhat liberal interpretation is required. From the long series in the Museum it appears that *licinia* is the common form; typical *dioptrica*, with the light fore wing, is not of frequent occurrence and not restricted to any area. The series extending from Arfak in the north to Kapur in the south shows that any of the forms may occur in any part of this area; *onesimides*, with the wide inner margin of the fore wing, and the white form are more frequent in the south, but not restricted to this part. It may be inferred that only one race is found in the western peninsula, and this is substantiated by the females. Some variation occurs without geographical locus; at the south of Geelvink Bay and further east changes occur and other distinct races appear.

Regarding the female of this species, some confusion with the female of *T. artemis* has occurred. When I first studied *dioptrica* I formed the opinion that the female was free from yellow hairs, or had no yellow area, below the base of the hind wing on the upperside, and that this area might be greyish brown or more generally white ; in *artemis*, on the other hand, the yellow hair and yellow area were present, although the yellow might be only slightly indicated. Also, on the underside there is the enlargement of the costal border at and around the base of the hind wing in *dioptrica*, a feature lacking in *artemis*. Now, having access to the Rothschild collection, I have been able to extend my observations over a larger number of specimens and thus confirm my opinion ; further, dissections of the female genitalia have been made of both *artemis* f. *eleusina* and *dioptrica* from Sorong, and these differ one from the other. With the recognition of these features there should be no difficulty in assigning the females to their respective species, and the erroneous statements relative to them can be corrected. Fruhstorfer described *eleusina* as a second female form of *artemis* from Sorong. His type and also his female type of *dioptrica* f. *licinia* from Sorong are both in the Museum and show no yellow below the base ; I can discover no valid difference between them, although he assigned them to two different species. I have made a similar mistake and increased the confusion when describing *helice* as a second female form of *Tenaris artemis pedius* Brooks (1944). At the same time I made some remarks on the expansion of the costal border around the base. *Helice* must now be transferred to *dioptrica* as the female of the Gebi Island race.

There are two female forms of *dioptrica*, one in which the middle area of the hind wing is white, the other in which the brown border is continued to fill the wing, often lighter internally ; there is no difference on the underside.

Tenaris dioptrica dioptrica Snellen v. Vollenhoven (1860).

Habitat : Sorong, 1 ♂, 8 ♀. The lightly marked fore wing, darker at the apex and on the inner margin agrees with the description, and the underside agrees with the figured type. The ocellus at the anal angle may not be present ; below, the ocelli show much variation in size.

Tenaris dioptrica dioptrica f. *licinia* Fruhstorfer (1904).

Habitat : Sorong, 3 ♂. These agree with the type, which is in the British Museum. The ocelli on the underside vary considerably in size.

Tenaris dioptrica amitaba Fruhstorfer (1904). Genitalia, Pl. VI, fig. 22.

Habitat : Waigeu, 32 ♂, 18 ♀. There is little variation among the males ; the ocellus on the upperside may be absent, or conspicuously large with a yellow ring. The hind wing of the female has either a central white area, or the border extends in a paler shade to fill the wing ; the latter is the commoner form.

Tenaris dioptrica helice Brooks (1944).

Habitat : Gebi Island, 17 ♂, 5 ♀, including the types. A very regular series of the *licinia* type. The males are indistinguishable from the Waigeu race. Each specimen has a well developed ocellus on the upperside. I have mentioned previously that the female was originally described as a form of *artemis*. The female is distinguished from that of *amitaba* by the wider dark area around the base of the hind wing underside which extends widely on the anal margin to the tornus.

Tenaris dioptrica timesias Kirsch (1877).

Habitat: Jobi Island, 2 ♂, 3 ♀. One male has the light fore wing similar to *dioptrica* from Sorong, the other has a light border on the inner margin as in f. *onesimides*; in the females the white area of the hind wing is very pure, above and below.

Tenaris dioptrica dioptrica f. *aesculapus* Staudinger (1887).

Habitat: Jobi Island. Not certainly represented in the Museum. This appears to be an albinic form.

Tenaris dioptrica wattina Fruhstorfer (1904).

Habitat: Salawatti, 9 ♂, 4 ♀, including the types. The type represents the light form of *dioptrica*, the others f. *licinia*; there seems little to distinguish this race from those occurring on the mainland.

Tenaris dioptrica onesimides Fruhstorfer (1904).

The type and description of this insect are of a particular form having a white border on the inner margin of the fore wing, but a long series shows that these insects pass in varying degrees from the form *licinia*, with the uniformly coloured wing, to that with a full white border, and this development may extend to the almost entirely white wing of the albinic form, of which there is also a type under the same name.

As there is no clear correlation between marking and geographical location I have decided to apply this name to all specimens occurring in the area extending from Arfak in the north to Kapur and Etna Bay in the south, where lighter forms are more frequent; there is also a considerable uniformity among the females, indicative of only one race.

Habitat: Arfak, 6 ♂, 4 ♀; Dorey, 12 ♂, 8 ♀; Mum Island, 1 ♂; Mioswa Island, 3 ♂, 2 ♀; Wandamman Mountains, 2 ♂; Kapur, 30 ♂, 15 ♀; McClure Gulf, 1 ♂; Kapia, 1 ♂; Fak Fak, 4 ♂, 3 ♀; Etna Bay, 7 ♂, 1 ♀, including the types; Kapur, 2 ♂, 1 ♀; Etna Bay, 1 ♀ paratype.

At the extreme south of Geelvink Bay, in the Wangaar district a change occurs in both sexes.

Tenaris dioptrica onesimides form **onesiporus** f. n.

♂. Fore wing, upperside: Almost entirely white, greyish at the apex and on the inner margin. Underside: A large white median area. Hind wing: Outwardly a greyish brown border, as wide at the apex as the ocellus below, where it is also paler in colour, terminating at the tornus; a small ocellus with pale yellow and brown rings. Underside: The marginal border narrower than in *onesimides*, giving a more extended white central area.

♀. Upperside, both wings: The white areas very clear and more extended than in *onesimides*. Fore wing, underside: The white area large with a narrow dark border on the costa, expanding at the apex, tapering outwardly to vein 3, a broad dark band across the inner margin nearly reaching vein 3, and half filling the cell. Hind wing: A dark brown area broadly around the base continued to and narrowing on the costa to the ocellus, outwardly continued narrowly to terminate at the tornus, suffused inwardly. The ocelli large with prominent yellow and brown rings.

Habitat: Wangaar, 13 ♂, 3 ♀, including the types. Four specimens have dark fore wings, with lighter marking beyond the cell.

Tenaris dioptrica rileyi Hulstaert (1925).

The description of this insect leaves one in doubt as to what the "silky grey" of the fore wing indicates; accepting this as an albinic form, the description otherwise agrees with the specimens from the Eilanden River and Setakwa River; it is based on one male from Digoel, further to the east. Tentatively I have accepted these specimens from the Eilanden and Setakwa Rivers as representing this race. Females from the same locality as the males have the appearance of being correctly assigned to them, and a dissection of the genitalia shows difference from the female assumed to be that of *hyperbolus*. They are distinguished as the only female in the species having the dark border on the hind wing underside completely surrounding the white area.

Habitat: Oetakwa River, 13 ♂, 9 ♀; Eilanden River, Snow Mountains, 2–3000 ft., 4 ♂.

Tenaris dioptrica annella Stichel (1906).

Habitat: Humboldt Bay, 1 ♂, the type.

The type of *T. tainia annella* Stichel, which is the only recorded specimen, is in the Museum. It has some similarity to a paratype of *Tenaris tainia* Fruhstorfer, which is also in the Museum.[7] The fore wing has a narrow white area across the inner margin otherwise filled with dusky brown, thus resembling *dioptrica onesimides*. The yellow line on the costa which is prominent on all specimens of *dioptrica* is present, but not conspicuous and might be overlooked. The hind wing is also similar to *dioptrica*, but the colour of both wings is darker and distinct; the underside also resembles *dioptrica*. The wing form is rounder at the apex, but this is not a reliable distinction. There is no record of *dioptrica* occurring east of Geelvink Bay, so that one may justifiably assume that *annella* is the race of *dioptrica* from that district.

" *Tenaris dioptrica orientalis*" Rothschild (1916).

The male type cannot be found in the Tring Collection under *dioptrica* or elsewhere, but under *honrathi* a female bears Lord Rothschild's label "Type" and in MS. "*Tenaris dioptrica orientalis* Rothschild"; below is a second label "*honrathi* f. *auriflua*," the latter being the correct determination. Other specimens of *honrathi* bearing locality labels which agree with the places mentioned in the description of *orientalis* (1916, *Nov. Zool.* **23**: 304), i.e. Erima (Hagen), Astrolabe Bay and Constantinhafen (Whanes), are apparently in this series. I think there can be no doubt that *orientalis* is a synonym of *auriflua* Fruhstorfer (see *Tenaris honrathi ritsemae* Fruhstorfer).

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[7] See p. 224.

15. *Tenaris myops* C. & R. Felder, 1860.

Genitalia, Pl. VII, figs. 23–33. Specialized scales, Pl. III, fig. 10.

The subspecies which constitute the *myops* group are extremely puzzling; there are so many forms that appear to clash one with another, yet with a certain uniformity between them. Systematists who have studied this group are at variance one with another, having united and divided the races, basing their conclusions on the similarity of the wing pattern without giving due consideration to the genitalia.

The most recent arrangement is that of Lord Rothschild (*Nov. Zool.* **23** : 306) who gives no reasons for his grouping. I have found it necessary to make some alterations to this arrangement, and the names affected by these changes, and my reasons for making them are given below :

Tenaris myops misolensis Rothschild, Misol Island. There are only three males including the type and two females; it is therefore a rare insect. The pattern on the upperside closely follows that of *myops*, but on the underside it is different; the white area on the hind wing is very pure and extends to the outer margin, which in all specimens of *myops* carries a more extended dark border; thus it appears to belong to another species and represents the Misol race of *cyclops*, which I regard as a distinct species.

Tenaris myops verbeeki Fruhstorfer, Milne Bay. There is, I believe, only one male known, the type; two females are in the Museum. At first sight this insect may be mistaken for *kirschi* or *mailua*, and has been grouped with one or other of these; on critical examination I discovered features distinguishing it from both, so that this relationship is untenable. Two important differences are the elongate wing, with a slightly concave outer margin, and the brown scales under the hair-streak on the anal margin without the clearly defined boundary as in *myops*. It is therefore removed from *myops* and placed in a similar group of insects, reviewed under *Tenaris cyclops*.

Tenaris kirschi occidentalis Rothschild, Kapur. A rare insect. The elongate wing resembles that of *cyclops*; this, together with other features in which it differs from *kirschi* (*myops*), led me to suspect that it did not belong to that species. There is also a close resemblance to *Tenaris cyclops acontius*, to which species in fact it belongs.

Tenaris kirschi interfaunis Rothschild, Humboldt Bay. The male type is somewhat similar to *Tenaris perplexus* Rothschild, but differences exist which preclude its reference to that insect and the relationship to *myops* (*kirschi*) must be ruled out. However, there is a clearer agreement with four males from Humboldt Bay which belong to the *cyclops* group although I hesitate to accept them with certainty as *interfaunis*. I have tentatively assigned them as representing this race, while *Tenaris perplexus* is undoubtedly a form of the race *myops merana*.

Tenaris kirschi convergens Rothschild, Fergusson Island. The male armature shows that this insect belongs to *mailua*, and it is therefore removed to that species.

Tenaris rothschildi parallelus Rothschild, Misol. As *rothschildi* has, hitherto, been considered a separate species it is not included in Rothschild's list, but described in a previous paragraph. This insect agrees in all essentials with *myops* from Aru, the only difference being in detail, and it seems that some confusion has arisen between *mysolensis* and *parallelus* in assigning the former to *myops* and the latter to *rothschildi*; I have shown previously that *mysolensis* does not belong to *myops* whereas *parallelus* represents the race of *myops* from Misol.

If one considers the dark forms of *rothschildi* and the gradation of colour ranging to the lightly coloured races, there is no clearly defined boundary between *myops* and *rothschildi*; and as there is no marked change in the male sex armature, it is impossible to regard them as separate species; for this reason *kirschi* is placed under *myops*. It will be noticed that each of these races occupies a well-defined area, and that they conform to a pattern typical of the area, and show with *artemis* a remarkable similarity in this change of pattern; so closely do they approach that in some of the races it is only by the yellow area at the base of the wing in *artemis* that they can be distinguished from each other on cursory examination. The following list gives the most striking parallels:

Locality.	*T. myops.*	Similar form of *T. artemis.*
Misol . . .	*parallelus*	*ziada.*
Aru . . .	*myops*	*myopina.*
Humboldt Bay .	*rothschildi*	*humboldti.*
Mandated Territory .	*wahnesi* (light and dark forms)	*staudingeri.* (light and dark forms)
Brit. N. Guinea .	*kirschi*	*onesimus.*
Yule Island . .	*errhiphoria*	*jamesi.*
Goodenough Island .	*miscus*	*electra.*
Fergusson Island .	*fergussonia*	*electra.*

The male sex armature of each of the above-mentioned insects except *interfaunis* and *perplexus* has been exhaustively examined and shows that the clasps of *myops*, *kirschi* and *rothschildi* are similar. No constant difference of specific importance distinguishes one race from the other, but *mailua* is at once separated from them by the wing of the clasp being very wide. The form of the gnathos separates *myops*, *kirschi* and *rothschildi* from *cyclops* and *mailua*; in the former, when viewed from the side, a projection or spur on the base section below the digit is seen. In *cyclops* and *mailua*, although the base is complex, there is no projection, as can be seen from the figures. A further distinction lies in the patch of specialized hair-scales under the anal hair-streak on the hind wing. In *myops*, *kirschi* and *rothschildi* it is always conspicuous as an irregular black patch; in *cyclops* and *mailua* it is small and confined to the base of the hairs, having a somewhat indistinct boundary.

Summary of the Subspecies and Forms of *Tenaris myops.*

Tenaris myops praxedes Fruhstorfer (1904).
Habitat: Salawatti, 1 ♂, the type.

Tenaris myops parallelus Rothschild (1916). Pl. *V*, and *Va*, fig. 7.

Habitat: Misol, 16 ♂, 15 ♀; Waigeu, 1 ♂, 2 ♀. I am unable to separate the specimens from these islands, where there appears to be only the one race.

Tenaris myops myops C. & R. Felder (1860). Specialized scales, Pl. III, fig. 10.

Habitat: Aru, 37 ♂, 19 ♀.

Tenaris myops merana Fruhstorfer (1907).

The single specimen, which is the type, of *Tenaris perplexus* Rothschild (1916) from Triton Bay, more nearly approaches the *rothschildi* forms of *myops* than anything else, both in wing pattern and locality of occurrence; in my opinion it is a form of *merana* from South Geelvink Bay, and is therefore included in this subspecies. *Merana* is represented in the Museum from Kadjumera Bay, 1 ♂; Kapur, 1 ♂ (Fruhstorfer's paratype), 1 ♀; Triton Bay, 1 ♂ (*perplexus*); Weyland Mts., 1000 ft., 1 ♂; Nomnagihe, S. of Wangaar, 2000 ft., 1 ♂; Upper Setakwa Riv., Snow Mts., 2–3000 ft., 1 ♀.

These specimens are not in good agreement. The type of *merana* from Kadjumera Bay is a larger insect, and when compared with the others, especially the paratype, appears to be aberrant. The males from the Weyland Mts. and Wangaar and also "*perplexus*" have the underside of the hind wing surrounded by a rather wide border, whereas in the others the border does not extend to surround the wing. Specimens with this variation appear in the *rothschildi* series but are not separable from the normal insect and hardly worth distinction as a form.

Tenaris myops maneta Hulstaert (1923).

Habitat: Merauke, S. Dutch N. Guinea. Not in the collection.

Tenaris myops vanhaasterti Hulstaert (1925).

Habitat: S.E. Dutch N. Guinea. Not represented in the Museum.

Tenaris myops ansuna f. *ansuna* Fruhstorfer (1904).

Syn. *Tenaris rothschildi* f. *laius* Brooks (1944).

Habitat: Jobi Island, 1 ♂ (type); Humboldt Bay, 8 ♂.

When I described the form *laius* the type of *ansuna* was not available. The descriptions of the forms of *ansuna* are difficult to follow, and as there was no specimen from Jobi in my *laius* series, I concluded that the more numerous insects from Jobi represented *ansuna*. Now that I have the type of *ansuna* I find it to be identical with that of *laius*, and that a series of 9 males from Jobi differ considerably from both *ansuna* and *rafaela*. These nine males appear to be the typical Jobi race and confined to this island.

Tenaris myops ansuna form **philammon** f. n.

Habitat: Jobi, 9 ♂.

♂. Fore wing: Pale fawn marking at the apex not extending below vein 5, more narrowly on the costa to the base, around which it expands nearly filling the cell, extending below nearly to the margin, leaving the lower outer two-thirds of the wing white. Underside: The marking dark brown, the white area less than in *ansuna*. Hind wing: The central white area bounded by a broad light fawn marginal border, which at the tornus is little more than edging. A small brown ocellus with a yellowish-brown ring. Underside: A wide dark brown border completely surrounding the wing, nearly as wide as the ocelli. Although the specimens show variation they are distinct from *ansuna*.

Tenaris myops ansuna f. *rafaela* Fruhstorfer (1905).

Habitat: Jobi, 5 ♂ (type); Humboldt Bay, 1 ♂. There is little variation in the series; the conspicuous yellowish hairs below the base of the hind wing are a distinctive feature.

Tenaris myops **phrixus** subsp. n.

♂. Fore wing upperside, as in *ansuna*, but the white area is much reduced, and also on the underside where it does not extend to the outer margin. Hind wing, as in *ansuna*, the ocellus has a light pupil and yellowish-brown ring. Underside: The wing is surrounded by a well-defined dark brown border, as broad on the costa and apex as the ocellus, narrow at the anal angle. Ocelli large with a prominent yellow ring.

Habitat: Andai, Dorey Bay, 5 ♂. This is an exceptionally uniform series.

Tenaris myops rothschildi H. G. Smith (1894). Genitalia, Pl. VII, fig. 23.

Habitat: Humboldt Bay, 20 ♂, 3 ♀ (types).

This race displays extensive individual variation in the ocelli, but these variations are secondary and may occur in any specimen. The type originated from Humboldt Bay and represents the race occurring from there to Geelvink Bay. To the East, over Mandated Territory, a very similar race occurs, described as *wahnesi*. It appears that some confusion of these two races exists, yet the distinction is easily discernible in the majority of the males, but the females are not distinguishable from one another.

rothschildi ♂.	*wahnesi* ♂.
Fore wing: The colour is slightly darker.	The apical marking wider, and suffused inwardly.
Hind wing underside: The band on the costal margin is wide at the base tapering toward the ocellus, where it is very narrow; at the apex about half as wide as the ocellus, tapering on the outer margin to end at the anal ocellus.	The costal band wide, extending around the base and continuing on the anal area, outwardly, as wide as the ocellus, narrowing to the anal ocellus, below which it continues narrowly to meet the band on the anal margin.

Tenaris myops rothschildi f. *pelagia* Fruhstorfer (1904) = *Tenaris senaria* Stichel (1906).

Habitat: Humboldt Bay, 11 ♂ (type). The series is distinguished from *ansuna* by the lightly marked underside. The type of *T. senaria* Stichel labelled Salawatti is in the Museum and the only specimen from this island, but as it agrees with *pelagia* from Humboldt Bay, a form most unlikely to occur on Salawatti, it appears that the locality label is incorrect.

Tenaris myops rothschildi ♀ f. *tainides* Fruhstorfer (1904).

Habitat: Humboldt Bay, 4 ♀ (type); Erina, 1 ♀; Fred. Will. Hafen, 2 ♀.

It will be noticed that this is the only female form recorded; although the wing pattern agrees with *pelagia* it is probably, also, the female equivalent of the other forms.

Tenaris myops wahnesi Heller (1894). Genitalia, Pl. VII, fig. 24.

There are 85 ♂, 19 ♀, taken at a number of localities in the Mandated Territory, on the North coast. There is considerable range in the extent of the marking ; the lightest form, *candida* Fruhstorfer (1904), in which little more than the apical brown remains, occurs chiefly in the Eastern part of the range, and is represented by 19 ♂ (type), 2 ♀.

Tenaris myops wahnesi f. *hadina* Fruhstorfer (1904).

Syn. *Tenaris tainia tainia* Fruhstorfer, 1905.

Habitat : Humboldt Bay, 1 ♂ ; Fr. Will. Hafen, 3 ♂ (type) ; Astrolabe Bay, 1 ♂ ; Mandated Territory, 1 ♀.

The type of *Tenaris tainia* Fruhstorfer is in Berlin. There is also a specimen from the Fruhstorfer collection in the British Museum bearing his label as "*Tenaris tainia*," presumably a paratype, from Fr. Will. Hafen. The underside of this agrees with the illustration in Seitz (*Macrolep.*, **9**, Pl. 101*b*), which at the same time might represent several other species, and the original description (1905, Fruhstorfer, *Insektenbarse* **22** : 36) appears to apply to this specimen. It is not separable from *Tenaris myops wahnesi* f. *hadina* Fruhst., also from Fr. Will. Hafen, and a dissection of the genitalia shows agreement with *wahnesi*.

Tenaris myops kirschi Staudinger (1887). Genitalia, Pl. VII, figs. 29-33.

Habitat : Albert Edward Mts., 1 ♂ ; Waria Riv., 1 ♀ ; Kumusi Riv., 12 ♂, 7 ♀ ; Aroa Riv., 4 ♂ ; Moroka, 6 ♂ ; Dinwara, 3 ♂ ; Ekeikei, 1 ♀ ; Redscar Bay, 1 ♂ ; Mt. Cameron, 4 ♂, 1 ♀ ; Brown Riv., 5 ♂, 1 ♀ ; Argyl Bay, 1 ♂ ; Port Moresby, 5 ♂, 6 ♀ ; Cloud Mts., 1 ♂ ; Hydrographer Mts., 2500 ft., 13 ♂, 5 ♀ ; Collingwood Bay, 1 ♂, 2 ♀ ; Mailu, 2 ♂ ; Milne Bay, 12 ♂, 4 ♀.

The series shows a decided tendency to local variation, the pattern becomes darker and more extended, and the insects larger as they approach the East. Some specimens may be confused with *mailua*, in which the marking is very similar, but they are easily distinguished by the yellow ring of the anal ocellus on the underside being completely surrounded by a black outer ring, in contrast to the absence of the black ring, internally in *mailua*. This is a constant feature in the male but the female shows some exceptions ; further distinctions are mentioned under *mailua*.

Two females from Milne Bay are possibly aberrant forms, but as they are distinctive and differ from *kircshi* I have decided to describe them :

Tenaris myops kirschi ♀ form **aliana** f. n. Pl. V and V*a*, fig. 8.

Fore wing : Upper and underside as *kirschi*. Hind wing : The dark greyish-black border on the costa, faintly near the base, widely at the apex, and outwardly to fill nearly half the wing, terminating at the tornus then continued as a narrow edging to the base. The anal ocellus small with a yellowish grey ring. Underside : The costal border extending over vein 7 enclosing the ocellus at the apex, then forming a somewhat angular contraction between the ocelli, broadly at the tornus and above the ocellus as a semicircle, continued narrowly to the base. The ocelli very large, with a white iris, and surrounded by a wide yellow ring, that at the apex the largest.

Habitat : Milne Bay, 2 ♀.

Tenaris myops kirschi f. *errhephoria*[8] Fruhstorfer (1915) = *T. myops kirschi* Staudinger.

Habitat: Finchafen, 1 ♂ (type); New Guinea, 1 ♂.

This insect appears to be a form of *kirschi*, and of no subspecific standing.

Tenaris myops kirschi f. *errhiphoria*[8] Fruhstorfer (1915).

Habitat: Yule Island, 2 ♂ (type); Dinawa, 2 ♂; Port Moresby, 1 ♂.

A lightly marked form of *kirschi* (see p. 224).

A very lightly marked form which appears to be characteristic of Yule Is.

Tenaris myops miscus Fruhstorfer (1905). Genitalia, Pl. VII, fig. 28.

Habitat: Normanby Island, 1 ♂ (type); Goodenough Island, 12 ♂, 9 ♀.

Tenaris myops fergussonia Fruhstorfer (1904). Genitalia, Pl. VII, figs. 25, 26.

Habitat: Fergusson Island, 24 ♂, 17 ♀ (including types); Trobriand Island, 1 ♂; Woodlark Island, 1 ♂, 1 ♀.

On Fergusson Island large and small forms occur, the difference in size appearing to be the only difference between them; the average wing span of five specimens of each variety is 9·9 cm. against 8·5 cm., the maximum for the single insect is 10·4 and 8·6 cm.

Tenaris myops fergussonia f. *crus* Brooks, (1944). Genitalia, Pl. VII, fig. 27.

Habitat: Fergusson Island, 4 ♂ (type).

16. *Tenaris mailua* Grose Smith, 1897.
Genitalia, Pl. VII, figs. 34, 36–39.

The features of the genitalia and ocellus which distinguish this species from *myops* have already been mentioned under *myops*.

Tenaris mailua mailua Grose Smith (1897).

Habitat: Lower Mambare Riv., 1 ♂, 2 ♀; Kumusi Riv., 1 ♀; Hydrographer Mts., 2500 ft., 2 ♂, 3 ♀; Mailu, 4 ♂, 1 ♀; Milne Bay, 15 ♂, 12 ♀; Samarai, 1 ♀.

Specimens showing an ocellus on the upperside occur among both sexes. They are not common and the ocellus ranges from a black spot to the full ocellus with white pupil and yellow ring.

Tenaris mailua mailua f. *littoralis* Rothschild (1916).

An indefinite form of no significance.

Tenaris mailua convergens Rothschild (1916).

Syn. *Tenaris kirschi convergens* Rothschild.

Mentioned under the review of the *myops* group (p. 220).

Habitat: Fergusson Island, 2 ♂ (type); 1 ♀ labelled New Guinea. Although the origin of this female is uncertain, it so closely resembles the male that I accept it, tentatively, as belonging to this race.

[8] These two names differing only in a single letter are proposed by Fruhstorfer in the same paper (1915, *Iris*, 29 : 91, 92).

Tenaris mailua rosseli Fruhstorfer (1905).

Habitat: Rossel and Sudest Islands, numerous specimens of both sexes, including the type.

17. *Tenaris cyclops* Staudinger, 1893.

Genitalia, Pl. VII, figs. 35, 40.

The races which constitute this species have previously been placed under various species with which they are not in good agreement; a striking similarity of characters justifies the grouping of these together as one species. The geographical occurrence of the races is orthodox, and follows the usual geographical variation in wing pattern. The oldest name for any of these races is *cyclops* Staudinger, 1893, which takes precedence over those more recently described.

While the general characters of the species are shown by the male, some of the females assigned to them are very similar to those of *dioptrica* and *myops*, but when compared with them they can be recognized chiefly in the larger white area of the fore wing, which is especially noticeable when series are compared. In the male the fore wing is elongate and the outer margin slightly concave in all the races. The dark races have a prominent and large white area across the wing, below the apex; on the underside the veins are strongly lined. The colour of the races ranges from black-brown to greyish-brown. An ocellus on the upperside is rare and has been found only in three specimens. The specialized scales under the hair-streak are often light brown with an indistinct boundary, also those on the "gland" are light. The genitalia have already been mentioned under *myops*.

Tenaris cyclops misolensis Rothschild (1916). Pl. V and V*a*, figs. 9 ♂, 10 ♀.

T. myops misolensis Roths.

Habitat: Misol, 4 ♂ (type), 2 ♀. This is a very dark form, following other species which occur on this island.

Tenaris cyclops occidentalis Rothschild (1916).

T. kirschi occidentalis Roths.

Habitat: Momi Coast Arfak, 2 ♂; Mt. Siwi, 800 m. Arfak, 1 ♀; Andai, Dorey Bay, 2 ♀; Wandesi, 1 ♀; Niney Valley, 1 ♀; Rom, Geelvink Bay, 1 ♀; Coast Dist., Geelvink Bay, 1 ♀; Kapur, 3 ♂ (type), 4 ♀; Wandamman Mts., 3 ♀; N. Guinea, 1 ♂.

Tenaris cyclops acontius Brooks, 1944. Pl. V and V*a*, fig. 11 ♂, 12 ♀. Genitalia, Pl. VII, fig. 35.

Habitat: Wangaar, S. Geelvink Bay, 3 ♂, 1 ♀ (types); Etna Bay, 1 ♀.

Tenaris cyclops acontius f. *theon* Brooks (1944).

Habitat: Uty Riv., 2 ♂ (type); Wangaar, 1 ♂; Wai Sai Riv., Weyland Mts., 1000 ft., 1 ♂.

Tenaris cyclops interfaunis Rothschild (1916).

T. kirschi interfaunis Roths.

Habitat: Humboldt Bay, 4 ♂ (type); Astrolabe Bay?, 1 ♂.

Tenaris cyclops cyclops Staudinger (1893). Genitalia, Pl. VII, fig. 40.

Habitat: Fr. Will. Hafen, 6 ♂, 3 ♀; Constantinhafen, 10 ♂, 1 ♀; Lower slopes Finisterre Mts., 1 ♂; Finchafen, 1 ♀; German New Guinea, 5 ♂, 2 ♀.

This is a race occurring in the Mandated Territory and, as one would expect, in this district the marking is somewhat different from that of the races already described, the yellow area on the hind wing being very prominent It is a variable insect; several forms have been named which are hardly worthy of recognition, while others could be added to these if there were any point in in doing so. Among the males six are without the anal ocellus, underside, both hind wings, i.e. typical; two are asymmetric. Of the females five are without the anal ocellus.

Tenaris cyclops verbeeki Fruhstorfer (1904). Pl. V and V*a*, fig. 13 ♂, 14 ♀.

Habitat: Milne Bay, 1 ♂ (the type), 2 ♀.

The illustration of this insect given by Fruhstorfer (*Wien. ent. Zeit.* **24**: Taf. 1) does not represent the type; it is a dark specimen of *kirschi* or *mailua* mistaken for *verbeeki*.

18. *Tenaris chionides* Godman & Salvin, 1880.

Genitalia, Pl. VII, figs. 41, 42, 43.

Tenaris chionides chionides Godman & Salvin (1880) Genitalia, Pl. VII, fig. 43.

Tenaris chionides, although smaller, very closely resembles *Morphotenaris* in form and wing marking, but dissections of their genitalia show that they are unrelated; those of *Morphotenaris*, though distinctly different, are somewhat similar to those of the *catops* group of *Tenaris*, while *T. chionides* has the typical *Tenaris* structure of the more complicated form.

The type is a female alleged to have come from Port Moresby. No male from this district is in the Museum, and all other specimens originate from distant districts. Thus some uncertainty exists as to the race it represents. However, as the type agrees with other females from British Territory it may be assumed that the males of these represent the race *chionides chionides*, shown by a long series of both sexes, ranging from Yule Island, the Aroa and Angabunga Rivers to the Hydrographer Mts. in the north. On the Hydrographer Mts. a change in form occurs, which I described as *Tenaris chionides* f. *superarvana* Brooks (1944) (Pl. V, V*a*, fig. 15) from two females in the Joicey Coll. With the acquisition of the Rothschild Coll. there is now a long series of both sexes in the Museum which shows that the male is similar to the female, and very distinct from *chionides* f. *aroana* Fruhstorfer. The type of the latter has a narrow brown band across the fore wing, which is not common and appears also in *chionides kubaryi*. Two females from the Rawlinson Mts. appear to belong to the form *superarvana*, but the border on the fore wing costa is wider than on *chionides chionides*, extending below the subcostal. A male from Baigi, Mambara, at 5000 ft., a very distinctive insect of the *superarvana* type, has the hind wing upperside similar to *superarvana* but the black marginal edging is wide from the anal angle to the base, and on the underside a submarginal border 2–3 mm. wide completely surrounds the wing, inwardly, broadly suffused into the white.

Habitat: Port Moresby (1 ♀ type), Angabunga Riv., 6000 ft., Upper Aroa Riv., 5000 ft., 20 ♂, 21 ♀; Yule Is., 2 ♀; Maroka, 1 ♂; Brit. N. Guinea, 4 ♂; Rawlinson Mts., 1 ♂, 3 ♀.

Tenaris chionides kuberyi Stichel (1893). Genitalia, Pl. VII, figs. 41, 42.

Habitat: Constantinhafen, 6 ♂, 5 ♀; Fr. Will. Hafen, 2 ♂, 3 ♀; Finchafen, 1 ♂; German N. Guinea, 2 ♂, 3 ♀; Rawlinson Mts., 1 ♀; British N. Guinea, 3 ♂ (doubtful origin).

This race occurs in Mandated Territory, and is distinguished from *chionides* by its smaller size; the white has a yellowish tinge and the marking is deep brown in colour. The forms *eugenia* and *cyclopides*, described by Fruhstorfer, are of little significance. The occurrence of a small anal ocellus on the hind wing underside is not unusual.

Among the above 14 ♂ and 12 ♀, 3 ♂ and 2 ♀ are of the form *aroana*.

19. **Tenaris alocus** sp. n. Genitalia, Pl. VII, fig. 44.

♂. Fore wing white, a yellowish-brown marginal border between the costa and subcostal veins, not quite reaching to the apex, white to grey on the inner margin to vein 1, nearly extending to the tornus, between veins 1 and 2, a greyish-brown band across the wing, hardly entering the cell. Underside: as above, but the marking dark brown, that on the costa extended to the apex, the lower band filling half the cell. Hind wing: greyish-brown marginal band on the costa narrowing at the apex and extending around the wing as a dark edging, nearly one-half the wing from the base filled with light yellow, in the anal area a light brown zone in which the hair-streak is darker; also a well developed hair-streak in the submedian fold. Underside: as above, but the marking deep brown and that in the anal area orange. The apical ocellus, only, large, with white pupil and prominent yellow ring; only the apical ocellus occurs on the underside of both sexes.

♀. Both wings, above and below, as in the male, but the bands are deep brown, with no white area on the inner margin of the fore wing, strongly yellow around the base of the hind wing.

This species closely resembles *T. chionides kubaryi* f. *aroana*, but may be distinguished from it by the slightly wider angle of the fore wing, also the light brown zone in the anal angle of the hind wing, and the white to grey streak on the inner margin of the fore wing. The female is more difficult to separate from that of *aroana*. The white area of the fore wing in *alocus* has a slight yellow tinge where *aroana* is pure white, on the hind wing the yellow area, both above and below, is more extended than in *alocus*, and the dark edging which surrounds the wing is hardly visible. The male sex armature shows the clasp apex truncate with no visible claws; this is a very distinctive and constant feature.

Habitat: Rawlinson Mountains (Keysser), 6 ♂, 1 ♀, including the type; Constantinhafen, 1 ♂, 2 ♀; Fr. Will. hafen, 1 ♀; Finchafen, 1 ♂; Mandated Territory, 5 ♂, 1 ♀; British New Guinea, 1 ♀. 7 ♂ show a very small anal ocellus, which is little more than a yellow spot.

20. *Tenaris horsfieldii* Swainson, 1820.

Genitalia, Pl. VII, figs. 45–47. Specialized scales, Pl. III, fig. 11.

Tenaris horsfieldi horsfieldii Swainson (1820). Genitalia, Pl. VII, fig. 45.

Habitat: Java, 15 ♂, 9 ♀; Palaboehan Rato (Wijnkoops Bay), 5 ♂, 2 ♀; Preangar, 5 ♂; Soekaboemi, 17 ♂, 2 ♀; Pekalongan, 1 ♂; Mid-Java, 4 ♂, 2 ♀; Soerabija, 2 ♂, 1 ♀; Pasoeroehan, 1000–1600 ft., 4 ♂, 1 ♀; Djampang (E. Java), 1 ♂; Djembei, 1300–2500 ft., 1 ♂; Mt. Gede, 4000 ft., 1 ♂; Malang, 2 ♂.

Specimens referable to the ocellar aberration *opulenta* Fruhstorfer, 5 ♂, 2 ♀.

Tenaris horsfieldii f. *morosa* Stichel (1906).

Habitat: Soekaboemi, 5 ♂, 1 ♀.

Tenaris horsfieldii ab. *acosmeta* Brooks (1944).

Habitat: Soekaboemi, 1 ♂ (type).

Tenaris horsfieldii occulta H. G. Smith (1889). Genitalia, Pl. VII, fig. 46.

Habitat: Borneo, Kina Balu, 5000 ft., 13 ♂, 17 ♀; Laulikan, Prov. Clark, 5000 ft., 1 ♂; Lawas, 1 ♂; Bruni, 1 ♂; Mt. Marapok, Prov. Dent., 2 ♂; Malinau, Mt. Molu, Labuan, 1 ♂, 1 ♀; Pontianak, 1 ♀. These include three examples of ab. *opulenta*.

Tenaris horsfieldii birchi Distant (1883).

Habitat: Johore, 1 ♀ (neoallotype), Mandeheling, W. Sumatra, 1 ♂ (Hagen, ex Rothschild Coll.).

This is a distinct race which nearly approaches *occulta*, but can be distinguished from it by the much reduced dark area below the base on both sides of the hind wing. The Museum specimens confirm Moulton's remarks on this insect (1915, *Sarawak Mus. J.* **2** : 6, 212). It is of interest to note that *birchi* and *occulta* have an extended white area on the hind wing above and below, with the almost complete absence of a marginal border, differing in this respect from the Java and Palawan races, which more closely resemble each other than that on the intervening island, Borneo. The late Dr. Corbet informed me that it is doubtful if more than ten specimens have been taken in Johore, where it is largely confined to the mangrove swamps, but occasionally found on the wooded hills of S. Johore.

Tenaris horsfieldii plateni Staudinger (1889). Genitalia, Pl. VII, fig. 47.

Habitat: Palawan, 20 ♂, 4 ♀. There is only one specimen of the ocellar aberration *lacrimans* Fruhstorfer.

21. *Tenaris butleri* Oberthür, 1880.

Genitalia, Pl. VII, fig. 48. Specialized scales, Pl. III, fig. 12.

Tenaris butleri butleri Oberthür (1880) (= *Tenaris pleiops* Kirsch, 1883).

Habitat: Lower Aroa Riv., 14 ♂; Yule Is., 4 ♂, 3 ♀; Port Moresby, 6 ♂, 2 ♀; Brown Riv., 1 ♂, 1 ♀; Astrolabe Range, 1 ♀; Tapulanis Ranges, 1 ♂; Samarai, 1 ♀; British N. Guinea, 7 ♂, 1 ♀.

22. *Tenaris dimona* Hewitson (1862).

Genitalia, Pl. VII, figs. 49-54. Specialized scales, Pl. III, fig. 15.

This species appears first on Ceram and is found distributed thence over the western islands and mainland of New Guinea where its extent is limited to Mandated Territory in the north, and Yule Island in the south; it is still unrecorded from eastern Papua and the islands. Over this large area the stability of marking is conspicuous, and there is not the marked change in pattern or massing of colour which is shown by the majority of species when passing from west to east. Minor changes in detail, associated with geographical location, account for the large number of described races. In some areas it appears to be a common insect.

Tenaris dimona dimona Hewitson (1862). Genitalia, Pl. VII, figs. 49, 50.

Syn. *Tenaris desdemona* Staudinger, 1887.
,, *T. dimona* f. *desdemona* Stgr., Brooks, 1944.

Habitat: Ceram, 15 ♂, 8 ♀.

Tenaris dimona subsp. ?

Habitat: Ambon, 1 ♂.

Tenaris dimona offaka Fruhstorfer (1905).

Habitat: Waigeu, 7 ♂, 3 ♀.

Tenaris dimona dimonata Stichel (1906).

Habitat: Salawatti, 5 ♂, 1 ♀.

Tenaris dimona didorus Brooks, 1944.

Habitat: Mysol, 10 ♂, 2 ♀.

Tenaris dimona aruensis Brooks, 1944. Genitalia, Pl. VII, fig. 53.

Habitat: Aru, 6 ♂, 3 ♀.

Tenaris dimona sorronga Fruhstorfer (1905).

Habitat: Sorong, 2 ♂.

Tenaris dimona anna Fruhstorfer (1915).

Habitat: Arfak Mts., 4 ♂.

Tenaris dimona kapura Fruhstorfer (1905).

Habitat: Kapur, 65 ♂, 3 ♀; Fak Fak, 1 ♂; McClure Gulf, 2 ♂; Coast District, Geelvink Bay, 2 ♂; Wangaar, 7 ♂, 3 ♀; Kwatizore, 2 ♂; Nomnagihe, 5 ♂; Djalan Riv., 1 ♂.

Tenaris dimona zaithe Fruhstorfer (1914). Genitalia, figs. 51, 52.

Habitat: Oetakwa Riv., 3500 ft., 7 ♂, 1 ♀; Upper Setakwa Riv., 2–3000 ft., Snow Mts., 10 ♂, 2 ♀; Utakwa Riv., Base Camp, Sea level, 1 ♂; Eilanden Riv., 9 ♂, 4 ♀.

Tenaris dimona microps f. *microps* H. G. Smith (1894). Genitalia, fig. 54.

Syn. *Tenaris microps* H. G. Smith (1894).

The dissection of the male sex armature shows that this insect is not separable from *dimona*. The type is unfortunately an abnormal form of the subspecies.

Habitat: Humboldt Bay, 2 ♂, including the type.

Tenaris dimona microps f. *trita* Stichel (1906).

Habitat: Humboldt Bay, 22 ♂, 5 ♀. This is the normal form of the subspecies.

Tenaris dimona microps f. *dinora* H. G. Smith (1896).

The form having ocellar aberration described by Smith, 4 ♂, 1 ♀, including the type.

Tenaris dimona areia Fruhstorfer (1904).

Although this was described by Fruhstorfer as an aberration, the long series show that it is a good subspecies.

Habitat: Constantinhafen, 3 ♂, 2 ♀; Fr. Will. Hafen, 3 ♂, 7 ♀; Erina, 1 ♀; Stephensort, 7 ♂, 4 ♀; Astrolabe Bay, 8 ♂, 4 ♀; Finchafen, 1 ♂.

Tenaris dimona thaema Fruhstorfer (1915).

Habitat: Finchafen, 3 ♂; Simbang, 1 ♂, 1 ♀; Sattelberg, 4 ♂, 2 ♀; Rawlinson Mts., 7 ♂, 4 ♀; Finisterre Mts., 1 ♂.

Tenaris dimona sophaineta Fruhstorfer (1914).

Habitat: Yule Is., 2 ♂ (type).

23. *Tenaris diana* Butler, 1870.

Genitalia, Pl. VIII, fig. 55. Specialized scales, Pl. III, fig. 16.

Tenaris diana diana Butler (1870).

Habitat: Batjan. Numerous specimens of both sexes.

In this race various additional ocellar aberrations are frequent; one of these, ab. *pseudodomitilla* Bakker (1944, *Zool. Meded.* **23** : 3–4, 191, pl. x, figs. 1, 2) has been mentioned recently. The type is from Halmahera; there are two females from Batjan in the British Museum.

Tenaris diana diadema Fruhstorfer (1905).

Syn. *Tenaris diana bisae* Rothschild (1916).

Habitat: Obi, a common insect, ♂ and ♀; Pulo Bisa, near Obi (*bisae*).

The specimens on which Lord Rothschild founded this race (2 ♂, 1 ♀) are in the British Museum. I am unable to distinguish the male type from the

Obi race for the features mentioned in the description are not very distinctive and occur in some specimens from Obi; also, the single ocellus of the second male is of no diagnostic value. The female, which possibly led Lord Rothschild to consider this distinct from *diadema*, does not belong to *diana*, but is a female of *Tenaris macrops macropina*, which also occurs on Obi. Not only does the general appearance suggest this, but the identity is confirmed by the black costal border on the hind wing underside, common to all female *macrops*, but absent in *diana*.

Tenaris diana leto Fruhstorfer (1905).

Habitat: Halmahera, 15 ♂, 8 ♀. Additional ocelli do not occur so frequently in this race.

24. *Tenaris urania* Linné, 1758.

Genitalia, Pl. VIII, figs. 56–58.

Tenaris urania urania Linné (1758).

Habitat: Amboina, Saparua, a common insect.

Tenaris urania urania f. *jairus* Cramer (1775).

This form is a lightly marked female having an additional anal ocellus, and similar to ab. *opulenta* Stichel; it is not of common occurrence, nor is it worthy of particular notice.

Tenaris urania urania f. *nox* Kirby (1901).

In this form the underside of both wings is completely black; this occurs more commonly in the males of each race, but chiefly in *urania*, of which the specimens are numerous.

Tenaris urania urania ab. *duplex* Stichel (1906).

This aberration is not common, but it occurs in both sexes, and in all races.

Tenaris urania pandermos Fruhstorfer (1911).

Habitat: Ceram and Gisser Island. A common insect.

Tenaris urania hollandi Fruhstorfer (1905).

Habitat: Buru. There are numerous specimens, but it appears to be less common than the other races, on their respective islands. It is a race which appears very subject to aberrations in the ocelli, for 60 per cent. of the females show nearly all the additional ocellar aberrations which have been described, but in the males there are few.

25. *Tenaris artemis* Snellen van Vollenhoven, 1860.

Genitalia, Pl. VIII, figs. 59–79. Specialized scales, Pl. III, figs. 13, 14.

Although the wing pattern of *Tenaris artemis* is similar to that of *Tenaris myops*, it is easily distinguished by the absence of the patch of dark scales under the anal hair-streak on the hind wing. Also on this wing there is a yellow area below the base in both sexes, which is faint in some specimens or, more rarely, absent in dark female forms. The usual geographical variation in wing pattern is very marked, but to divide the species into sections of light and dark races is unnecessary and artificial. Some account of the variation in marking that occurs in each race will be found under *artemis artemis*.

Tenaris artemis pedus Brooks (1944).

Habitat: Gebi Island, 19 ♂, 3 ♀.

Tenaris artemis grisela Fruhstorfer (1904).

Habitat: Waigeu, 33 ♂, 28 ♀. The figured example of *grisela* Fruhstorfer (1905, *Wien. Ent. Zeit.* **24** : 74, 121, T.g.t. 1) represents a specimen between the normal and extremely dark forms. The latter has been described by Fruhstorfer as *timesides* (1905).

Tenaris artemis celsa Fruhstorfer (1904).

Habitat: Salawatti, 1 ♂, 3 ♀.

Tenaris artemis ziada Fruhstorfer (1904).

Habitat: Misol, 10 ♂, 9 ♀.

Tenaris artemis myopina Fruhstorfer (1904).

Habitat: Aru, 35 ♂, 20 ♀.

Tenaris artemis artemis Snellen van Vollenhoven (1860). Genitalia, figs. 59, 60.

Fruhstorfer mentions that the habitat of the specific type of this insect is uncertain (Seitz, *Macrolep.* **9** : 413) and in the original description no locality other than Dutch New Guinea is mentioned. He suggests Sorong, and this appears to be correct, although the type figured by van Vollenhoven (1860, *Tijdschr. Ent.* **3** : 37) is not in complete agreement with specimens from this place in the Museum, which differ only in variable details, however, and are certainly nearer to it than are insects from any other district in the Western Peninsula and Mainland.

The long series of specimens from various parts of the peninsula shows considerable variation in marking, so that to fix distinct geographical races clearly is difficult. Dissection of the male sex armature does not help in separation, for while its structure has always the distinctive form of *artemis*, the form of the clasp shows great variety, and this I have found to occur with all the races of this species. Despite these difficulties there appear to be two distinct races, and a form occurring in the extreme west, namely *artemis*, ranging from Sorrong, over the north to Dorey, *zenada* in the south, from Kapur and Fak Fak, and extending to South Geelvink Bay and *zenada* form *chares* f. n. which appears in South Geelvink Bay as a mountain form, extending to the north on the west of Geelvink Bay. Races occurring further east are distinct and receive special mention.

Habitat: Sorong, 7 ♂, 6 ♀; Coast near Arfak (= Wariab), 5 ♂; Momi Coast, 5 ♂, 2 ♀; Amberforn Is., 1 ♀; Dorey, 15 ♂, 8 ♀; Mioswar Is., 1 ♀.

In these insects the yellow below the base of the hind wing is not very distinctive.

Fruhstorfer has described a dark form of *artemis* as f. *eleusina*, which he assumes occupies in regard to *artemis* a relationship similar to that which f. *timesides* holds to *grisela*; the type of *eleusina* is in the Museum with other specimens bearing his label as such, but as I have mentioned under *dioptrica*, *eleusina* is the female of that species, and the name becomes a synonym. Among the races of *artemis* dark forms are not unusual, specimens in a series often grade from normal to very dark; with the difficulty of deciding to which class any given specimen belongs it is better to avoid names, and refer to the specimen as a dark form of the race under consideration.

Tenaris artemis zenada Fruhstorfer (1904). Genitalia, Pl. VIII, figs. 67, 68.

Habitat: Kapur, 13 ♂, 9 ♀; Fak Fak, 1 ♂; McClure Gulf, 3 ♂, 3 ♀; Wangaar, 7 ♂, 7 ♀; S. Geelvink Bay, 2 ♂; Ned. New Guinea, 1 ♀; Momi River, 1 ♀.

Fruhstorfer's choice of the type for this race is unfortunate, as it closely resembles the form I am describing as *chares*, which differs on the underside. He must have been aware that his type differed from the dominant form, of which he had a series in his collection, two of which are labelled *zenada*, presumably paratypes. Further, with these before him, he described the race as "grey-black" (Seitz, *Macrolep*. **9**: 414) whereas in the long series they show the grey-brown of *artemis* in varying degrees, and the underside is much the same. In this race the yellow area on the hind wing is prominent.

Tenaris artemis zenada form **chares** f. n. Pl. V, V*a*, fig. 16. Genitalia, Pl. VIII, figs. 65, 66.

♂ Fore wing upperside: The white area as in *artemis*, the costal and inner marginal bands dark blackish-brown, the underside similar. Hind wing upperside: On the costal area greyish, suffusing into dark brown at the apex, where it is as broad as the ocellus on the underside, continued outwardly to the tornus, where it is reduced to a narrow edging to the base on the outer portion of the wing; the border is suffused inwardly and fills the lower half above the ocellus; a somewhat lighter area extends on the anal margin from the angle to the base; a yellow area below the base. The ocellus small with a greyish centre surrounded by an inconspicuous yellow ring. Underside: The blackish-brown costal band extends to vein 7, tapering toward the ocellus, outwardly nearly as wide as the ocellus at the apex, tapering to pass below, and free from the anal ocellus, continuing narrowly to the base; the white area very pure. Both ocelli well developed.

♀. Upperside: Both wings as in the male. Fore wing underside: As above, but lighter. Hind wing underside: The costal band follows vein 7 to the ocellus, a nearly black narrow border extends completely around the wing to the base, suffused inwardly at the apex. Ocelli as in the male.

Type, ♂ and ♀, Niney Valley, 3500 ft. (A. E. Pratt, ex Joicey Coll.).

Habitat: Mt. Siwi, 2600 ft., 4 ♂, 3 ♀; Angi Lakes, Arfak Mts., 6000 ft., 1 ♂; Yaour, 1 ♂; Djalan Riv., 1 ♂; Nomnagihe, 25 miles S. Wangaar, 2000 ft., 3 ♂; Wangaar, 3 ♂; Wangaar Riv., 600 ft., 2 ♂; Weyland Mts., 1000 ft., 1 ♂; Mili Coast, Wandamman, 1 ♀; Kajmera Bay, 1 ♂; Etna Bay, 1 ♂.

Races from the South, East of Etna Bay.

These races are clearly distinct from those occurring in the west. Although the type of marking among them is similar, their variation is very puzzling, and until more material which will definitely establish their relationship is available, the matter cannot be settled satisfactorily. Now, having the type of *Tenaris meeki* Rothschild (1916) available I am doubtful that it represents *intermedians* Hulstaert (1925). As I suggested previously (1944) it is a distinct and beautiful insect, differing in some features from other specimens occurring in near localities; the female with which Lord Rothschild associated it, is remarkable for its size and unusual marking, and is also different from other females from this region. Both undoubtedly belong to *artemis*. Only the types are known.

Habitat: Upper Setakwa Riv., 2–3000 ft., ♂; Oetakwa Riv. (near), 3500 ft., ♀.

The other specimens from this locality I have tentatively placed under *Tenaris artemis intermedians* Hulstaert (1925). I have not seen the type of this race and descriptions in many cases are unsatisfactory, so I put forward the possibility for what it is worth. The following summary of the specimens shows their conspicuous differences and the localities from which they originate. The marking of the females follows that of the males and undoubtedly represents the normal form of this sex.

4 ♂, 3 ♀, Oetakwa Riv., 3500 ft., of these 3 ♂, 3 ♀ are uniform above, 1 ♂ is broadly white below the apex of the fore wing; on the underside 1 ♀ has the hind wing almost entirely white.

Utakwa Riv., 1 ♂, 2500–3000 ft., 1 ♀, 4500 ft.; the ♂ is similar above and below to the 3 ♂ from the Oetakwa Riv., the ♀ has a much extended white area below the apex of the fore wing, the hind wing is also light. The only marking on the white underside of both wings is the narrow costal border on the fore wing, somewhat extended at the apex, and the ocelli on the hind wing.

1 ♀, Upper Setakwa Riv., 2–3000 ft. similar to the females from the Oetakwa Riv.; 3 ♂, 1 ♀, Eilanden Riv., presumably sea-level, 1 ♂ is albinic, the others both above and below are similar to the Oetakwa males. The ♀ is very distinct, having a broad defined border, outwardly, on the hind wing about one-fourth of the width of the wing and enclosing the anal ocellus; at the tornus it is reduced to little more than an edging continuing to the base; the underside is similar but the border wide on the anal margin.

Tenaris artemis madu Brooks (1944). Genitalia, Pl. VIII, figs. 63, 64.

Habitat: Biak and Bosnik, Schouten Is., 24 ♂, 10 ♀.

In my original description I accorded this insect specific rank, the marking being somewhat dissimilar to that of *artemis*, but dissection of the male sex armature proves the relationship to this species. This is another example of a butterfly from Schouten Island differing in marking from the norm of the species to which it belongs.

Tenaris artemis blandina Fruhstorfer (1904). Genitalia, Pl. VIII, figs. 61, 62.

Habitat: Jobi Is., 11 ♂, 3 ♀.

This is a variable race, the marking is like that of *humboldti*, but generally darker. Fruhstorfer's type is albinic and an unusual specimen; in extreme contrast to this there are two males with the white subapical area of the fore wing reduced to a few streaks between the veins, with the hind wing correspondingly dark.

Tenaris artemis humboldti Fruhstorfer (1904). Genitalia, Pl. VIII, figs. 69, 70, 71.

Habitat: Humboldt Bay, 33 ♂, 20 ♀.

Light and dark forms occur, while the former are not of frequent occurrence, as in *staudingeri*, the latter are pronounced in both sexes; the hind wing is often filled with light brown.

Tenaris artemis staudingeri Honrath (1889). Genitalia, Pl. VIII, figs. 72, 73, 74.

Habitat: Fr. Will. Hafen, 8 ♂, 13 ♀; Stephensort, 16 ♂, 6 ♀; Constantinhafen, 20 ♂, 8 ♀; Astrolabe Bay, 17 ♂, 3 ♀; Finchafen, 4 ♂, 7 ♀; Erina, 2 ♂, 4 ♀; Simbang, 5 ♂, 3 ♀; Sattelberg, 3 ♂, 1 ♀; Bongo ? 2 ♂, 3 ♀; German N. Guinea (without localities), 95 ♂, 39 ♀.

The warm brown marking of this race is subject to extensive variation; a number of forms have been described, and while the types are definite, many insects combine the features of two forms, either on the upper or underside, and grade one into the other. The following have been described:

Tenaris artemis staudingeri f. *albicans* Hagen (1897).
,, ,, ,, f. *nigricans* Hagen (1897).
,, ,, ,, f. *eos* Heller (1894).
,, ,, ,, f. *infumata* Fruhstorfer (1905).
,, ,, ,, f. *limbatus* Fruhstorfer (1905).
,, ,, ,, f. *artemides* Fruhstorfer (1905).
,, ,, ,, f. *simonetta* Fruhstorfer (1905).
,, ,, ,, f. *druentia* Fruhstorfer (1911).

Ocellar aberrations are numerous and include the various named forms. However, one female is exceptional, and I believe unique; it has the anal ocellus duplicated in space 3 on the upperside, and on the underside there is a chain of five ocelli as in form *rothschildi*.

Tenaris artemis reducta Rothschild (1915).

T. myops reducta Rothschild.

Habitat: Vulcan Island, 1 ♂ (type). This insect has white scales under the anal hair-streak and the genitalia are of the *artemis* type, with a small clasp wing and the curved apex set with large claws. It cannot belong to *myops*.

Tenaris artemis jamesi Butler (1876). Genitalia, Pl. VIII, fig. 75.

Syn. *Tenaris onesimus* Butler, 1877.

Syn. *Tenaris sticheli* Fruhstorfer, 1901.

Habitat: Kumusi Riv., 15 ♂, 14 ♀; Hydrographer Mts., 9 ♂, 3 ♀; Collingwood Bay, 2 ♀; Milne Bay, 15 ♂, 6 ♀; Samarai, 1 ♂, 1 ♀; Mailu, 1 ♂; Brown

Riv., 1 ♂; Aroa Riv., 2 ♂, 2 ♀; Dinawa, 2 ♂, 2 ♀; Ekeikei, 4 ♂, 3 ♀; Epa, 1 ♀; Yule Isl, 3 ♂, 2 ♀ (including f. *jamesi*, type); Ekeikei, 1 ♀.

The type of *jamesi* is a female aberration of very light marking; there is one other similar specimen from Ekeikei. The uniformity of specimens from north and south British N. Guinea, including Yule Is., shows that only one race occurs in this region, of which the type is a very rare form. There is 1 ♀ from Dampier Is.; two females from Batke Mts.,? 4–5000 ft., do not strictly agree with *jamesi*, but until the males are discovered they should remain undescribed.

Tenaris artemis zetes Brooks (1944).

Habitat: Murray Is., 1 ♂, 1 ♀. Types.

Tenaris artemis queenslandica Rothschild (1916).

Habitat: N. Queensland, 1 ♂. Type.

Tenaris artemis electra Fruhstorfer (1904). Genitalia, Pl. VIII, fig. 76.

Habitat: Fergusson Is., 12 ♂, 8 ♀; Goodenough Is., 6 ♂, 3 ♀; D'Entrecasteau Is., 4 ♂.

Tenaris artemis tineatus Fruhstorfer (1905).

Habitat: Woodlark Is., 8 ♂, 14 ♀.

Tenaris artemis affinis Kirby, (1889).

Habitat: Rossell Is., 6 ♂, 6 ♀.

Tenaris artemis affinis f. *barbata* Kirby (1889). Genitalia, Pl. VIII, figs. 77.

Habitat: Mt. Rossell, 2100 ft., 3 ♂, 4 ♀; Rossell Is., 2 ♂, 16 ♀.

One female shows a remarkable ocellar aberration. On the underside of the hind wing there are the two normal ocelli and between them a third ocellus appears as though burst into several irregular fragments which are yellow with a narrow dark outline surrounding each; some have a black centre.

Tenaris artemis melanops H. G. Smith (1897).

Habitat: Sudest Is., 9 ♂, 4 ♀.

Species, races and forms described since 1933.

(References for names published prior to 1933 will be found in Stichel, 1933, *Lep. Cat.* 54, Amathusiidae.)

acontius, *Tenaris*, Brooks, 1944 : 112.
acosmeta, *Tenaris horsfieldii* ab. Brooks, 1944 : 109.
aruensis, *Tenaris dimona*, Brooks, 1944 : 115.
crus, *Tenaris myops fergussonia* form, Brooks, 1944 : 113.
didorus, *Tenaris dimona*, Brooks, 1944 : 116.
dionus, *Tenaris mailua*, Brooks, 1944 : 113.
elatus, *Tenaris*, Brooks, 1944 : 110.

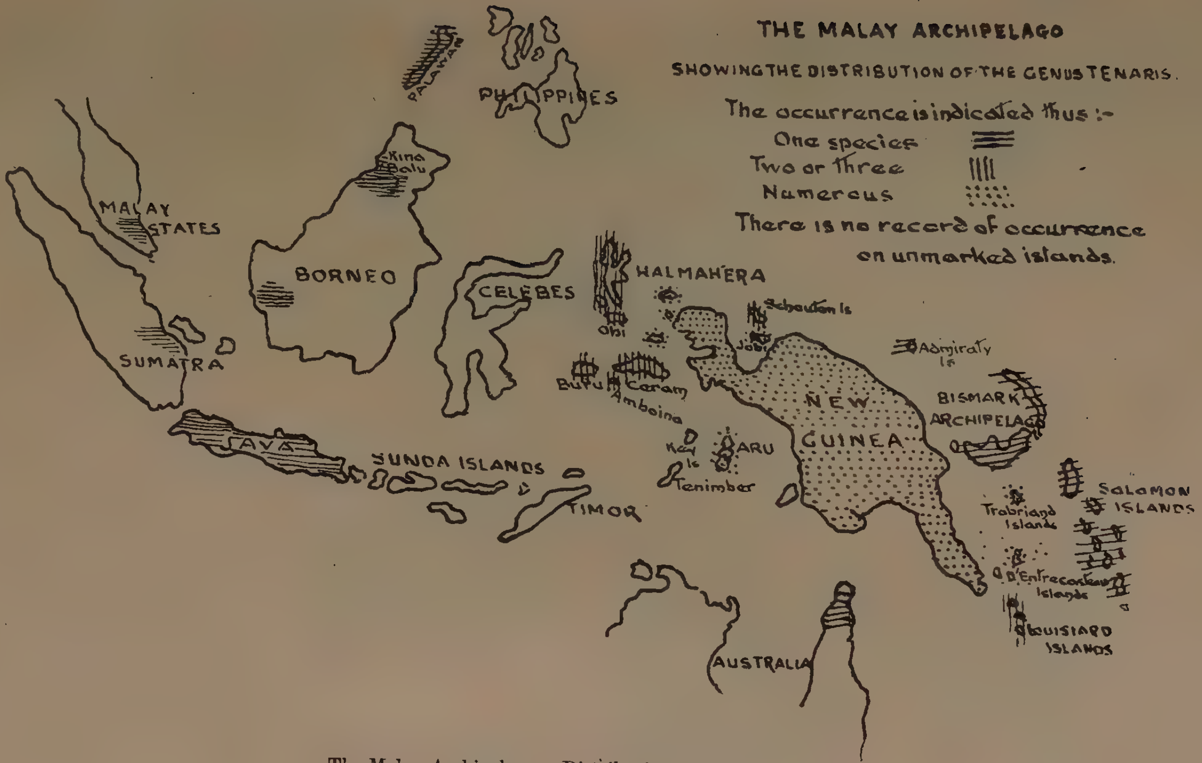
helice, *Tenaris artemis pedius* ♀ form, Brooks, 1944 : 113.
kumusii, *Tenaris catops*, Bakker, 1942 : 197. Pl. IX, fig. 3, 4.
laius, *Tenaris rothschildi* form, Brooks, 1944 : 111.
leanas, *Tenaris catops*, Brooks, 1944 : 111.
lucina, *Tenaris gorgo*, Brooks, 1944 : 116.
madu, *Tenaris*, Brooks, 1944 : 115.
pedius, *Tenaris artemis*, Brooks, 1944 : 113.
pellus, *Tenaris catops* form, Brooks, 1944 : 111.
pseudodomitilla, *Tenaris diana leto* form, Bakker, 1942 : 191. Pl. X, figs. 1, 2.
psola, *Tenaris macrops* ♀ form, Brooks, 1944 : 110.
shapur, *Tenaris onolaus* form, Brooks, 1944 : 110.
superarvana, *Tenaris chionides* form, Brooks, 1944 : 112.
sura, *Tenaris macrops*, Brooks, 1944 : 110.
theon, *Tenaris acontius* form Brooks, 1944 : 112.
thyia, *Tenaris gorgo*, Brooks, 1944 : 116.
yulei, *Tenaris gorgo*, Bakker, 1942 : 206. Pl. XI, fig. 3.
zetes, *Tenaris artemis*, Brooks, 1944 : 114.

REFERENCES.

BAKKER, D., 1942, Revision of the AMATHUSIIDAE in the Museums at Leiden and at Amsterdam. *Zool. Meded.* **23** : 172–216.

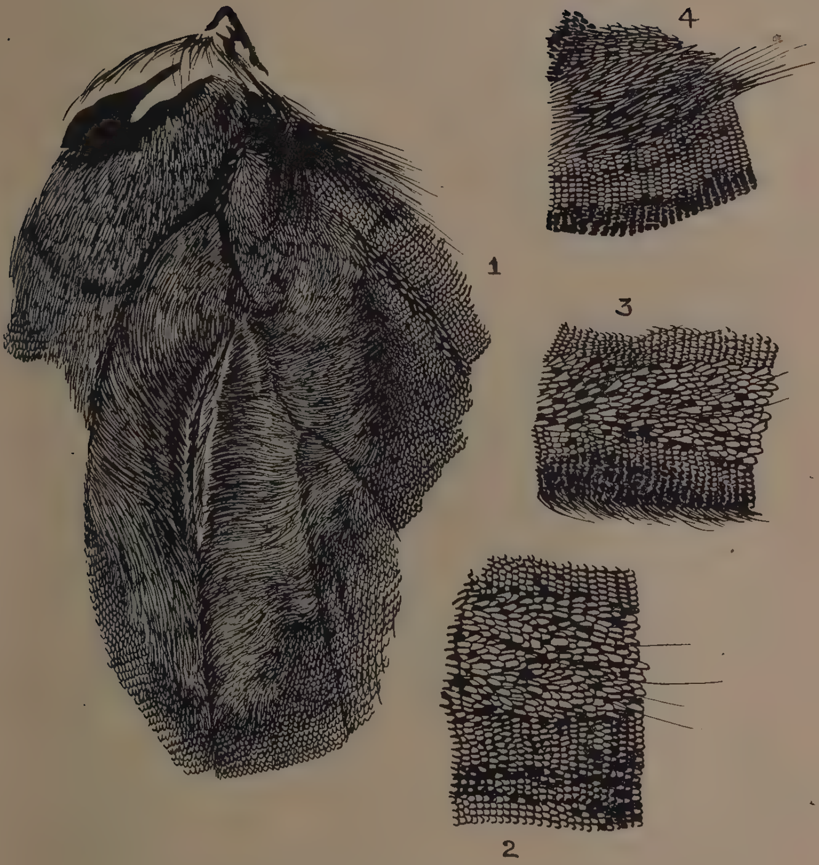
BROOKS, C. JOSLIN, 1944, New Species and Forms of *Tenaris* (Lep. AMATHUSIIDAE). *Proc. R. ent. Soc. Lond.* (B) **13** : 109–116.

(For references to earlier literature *see* Stichel, 1933, *Lep. Cat.* 54, AMATHUSIIDAE).



The Malay Archipelago. Distribution of the genus *Tenaris*.

PLATE II.



Enlarged drawings of the male sex scales *in situ*
on the hind wing, upperside.

(1) The " gland " on vein 7 of the hind wing of *Tenaris domitilla.*
(2) Oval specialized scales from below the anal hair-streak of *Tenaris bioculatus.*
(3) Blunt-ended elongate oval specialized scales of *Tenaris catops.*
(4) Elongate lanceolate specialized scales of *Tenaris horsfieldii.*

The hairtuft in No. 1, and the hairs in Nos. 2, 3, 4 have been removed, but a few remain to indicate their position.

PLATE III.

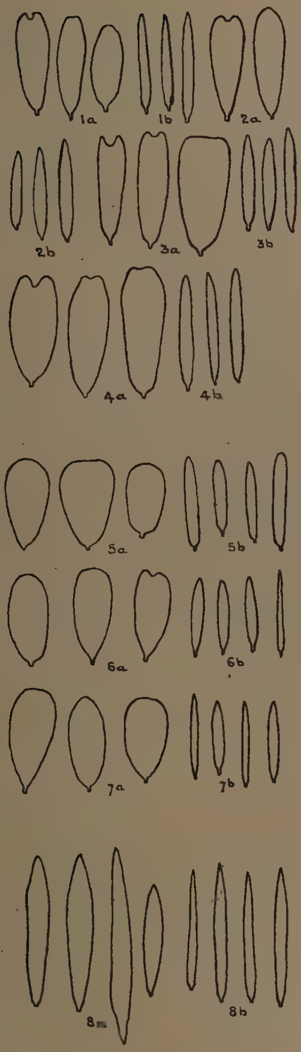
Specialized scales.

a = From below the anal hair-streak.
b = From the " gland."

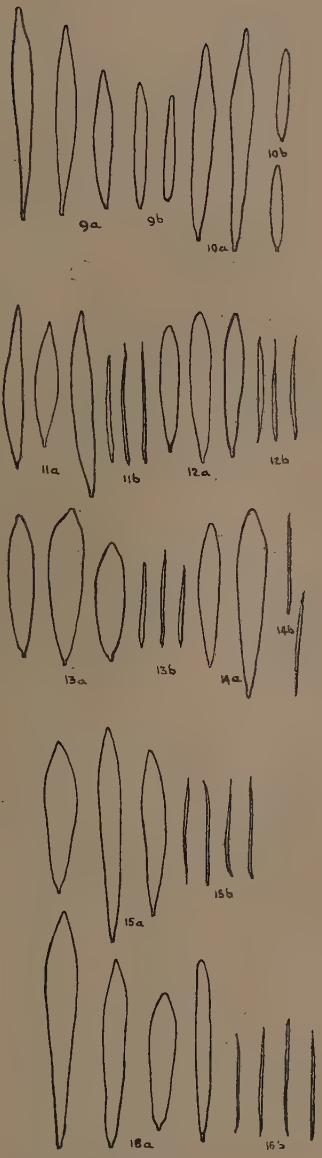
(Under the same magnification).

(1) *Tenaris phorcas* f. *phorcas.* Solomon Islands.
(2) *T. catops catops.* Aru.
(3) *T. macrops macropina.* Obi.
(4) *T. selene selene.* Buru.
(5) *T. bioculatus charonides.* Mandated Territory.
(6) *T. dina dina.* Mandated Territory.
(7) *T. gorgo gorgophone.* Mandated Territory.
(8) *T. domitilla agrippa.* Obi.
(9) *T. honrathi ritsemae.* Humboldt Bay.
(10) *T. myops myops.* Aru.
(11) *T. horsfieldii occulta.* Borneo.
(12) *T. butleri butleri.* British New Guinea.
(13) *T. artemis grisela.* Waigeu.
(14) *T. artemis staudingeri.* Mandated Territory.
(15) *T. dimona dimona.* Humboldt Bay.
(16) *T. diana diadema.* Obi.

PLATE III.

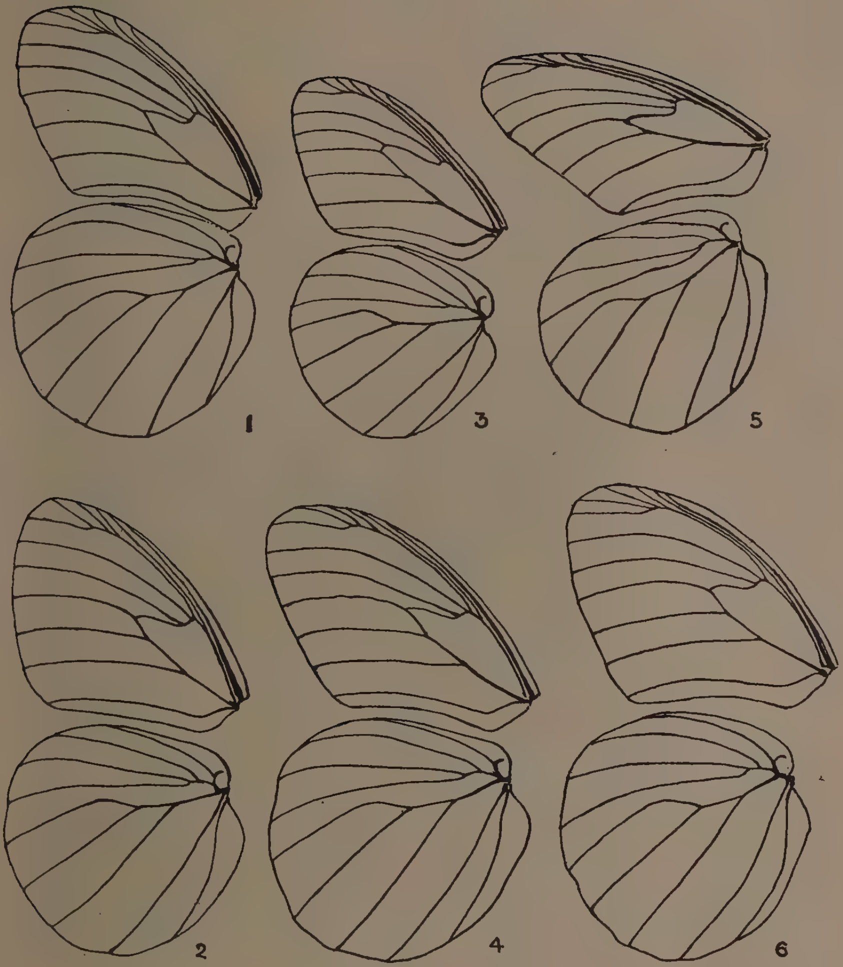


The genus *Tenaris.*



Specialised scales.

PLATE IV.



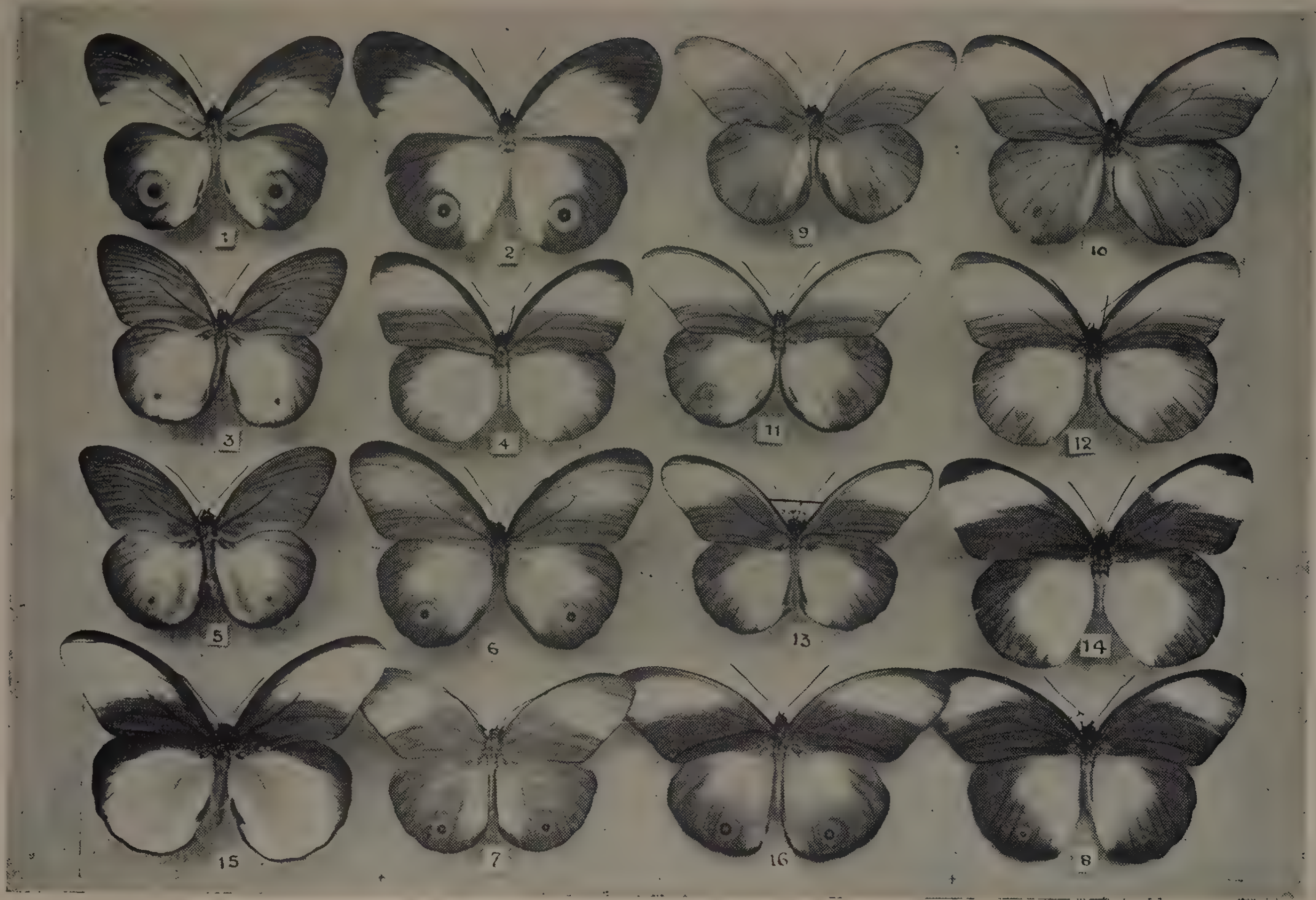
Typical examples of neuration and wing form.

(1) *Tenaris phorcas.*
(2) *T. gorgo.*
(3) *T. bioculatus.*
(4) *T. myops.*
(5) *T. horsfieldii.*
(6) *T. urania.*

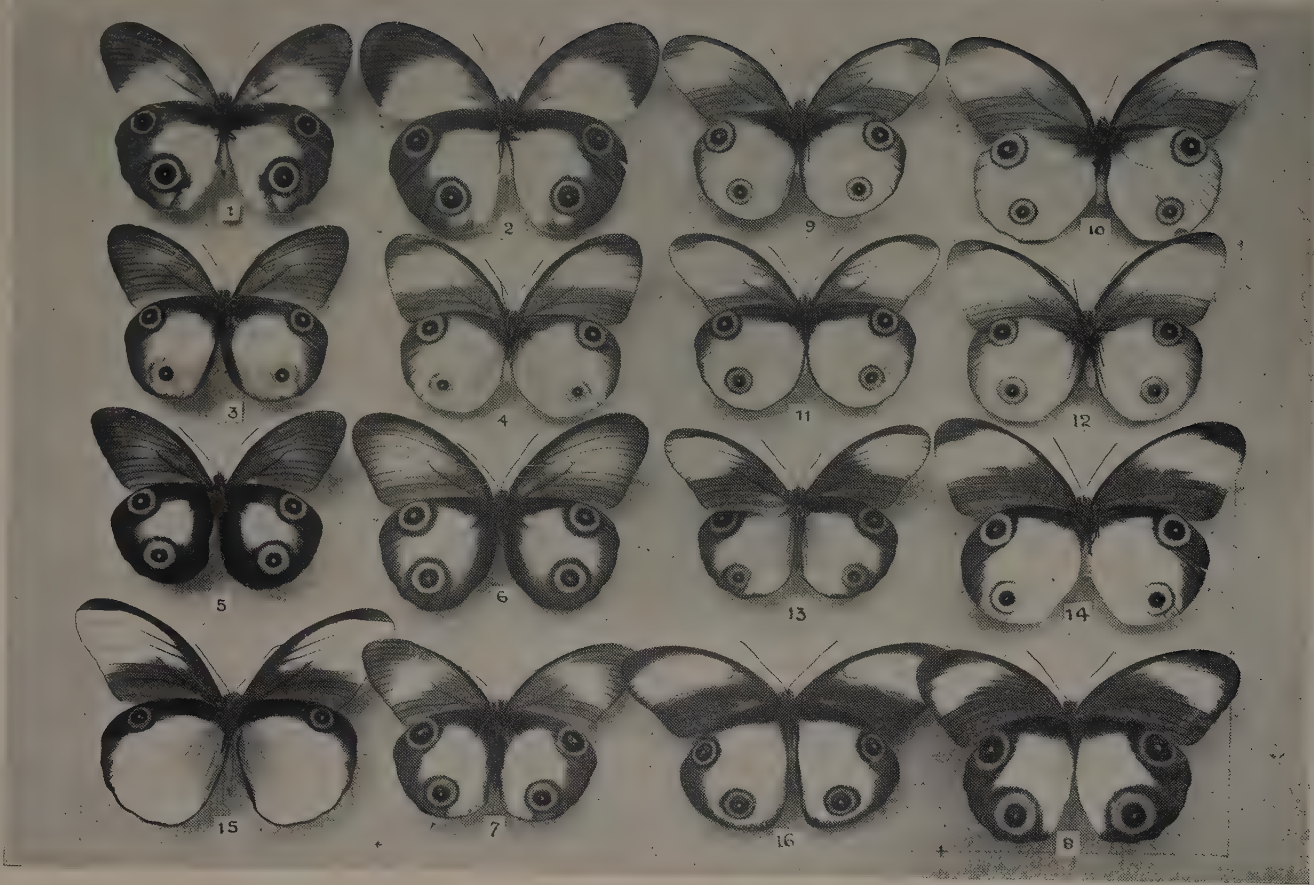
PLATE V, Upperside. PLATE V*a*, Underside.

Half natural size.

(1) *Tenaris catops dampierensis* Roths. ♂. Dampier Island.
(2) *T. catops dampierensis* Roths. ♀. Dampier Island.
(3) *T. montana montana* Stich. ♂. Ekeikei, Brit. N. G.
(4) *T. montana montana* Stich. ♀. Ekeikei, Brit. N. G.
(5) *T. hyperbolus versteegi* v. Eecke. ♂. Upper Setakwa Riv., Snow Mts.
(6) *T. hyperbolus versteegi* v. Eecke. ♀. Upper Setakwa Riv., Snow Mts.
(7) *T. myops parallelus* Roths. ♂. Mysol Island.
(8) *T. myops kirschi*. ♀. f. *aliana* form n. Milne Bay.
(9) *T. cyclops mysolensis* Roths. ♂. Misol Island.
(10) *T. cyclops mysolensis* Roths. ♀. Misol Island.
(11) *T. cyclops acontius* Brooks. ♂. Wangaar, D.N.G.
(12) *T. cyclops acontius* Brooks. ♀. Etna Bay, D.N.G.
(13) *T. cyclops verbeeki* Fruhst. ♂. Milne Bay.
(14) *T. cyclops verbeeki* Fruhst. ♀. Milne Bay.
(15) *T. chionides* f. *superarvana* Brooks. ♂. Hydrographer Mts., Brit. N.G.
(16) *T. artemis zenada* f. *chares* f.n. ♂. Ninay Valley, D.N.G.



The genus *Tenaris*

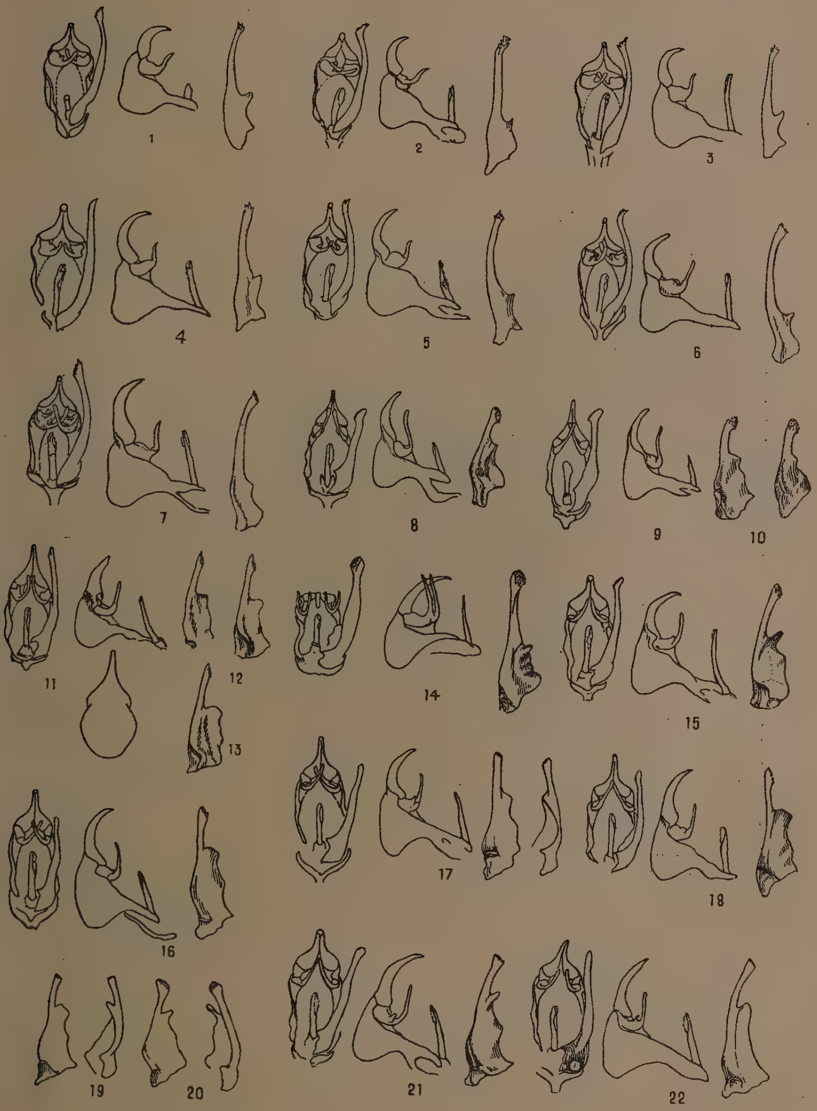


The genus *Tenaris.*

PLATE VI.

Male Sex Armature. Showing the dorsal and lateral view, with the inner aspect of left clasp, or, in some cases, only the clasp. (Not to scale.)

(1) *Tenaris catops fulvida* Butler. Mysol.
(2) *T. catops westwoodi* Staudinger. Mandated Territory.
(3) *T. catops mylaecha* Westwood. Sudest Island.
(4) *T. phorcas phorcas* Westwood. Guadalcanal, Solomon Islands.
(5) *T. phorcas admiralitatis* Rothschild. Admiralty Islands, Bismark Archipelago.
(6) *T. macrops macrops* Felder. Batjan.
(7) *T. selene selene* Westwood. Buru.
(8) *T. bioculatus charon* Staudinger. Port Moresby.
(9) *T. bioculatus bioculatus* Guérin. Waigeu.
(10) *T. bioculatus bioculatus* Guérin. Dorey.
(11) *T. gorgo gorgo* Kirsch. Sorong.
(12 and 13). *T. gorgo gorgo* Kirsch. Sorong.
(14) *T. dina dina* Staudinger. Mandated Territory.
(15) *T. domitilla agrippa* Fruhstorfer. Obi.
(16) *T. onolaus onolaus* Kirsch. Geelvink Bay.
(17) *T. montana montana* Stichel. Epa, Brit. N. Guinea.
(18) *T. honrathi ritsemae* Fruhstorfer. Mandated Territory.
(19) *T. onolaus shapur* Brooks. Wandamman Mountains.
(20) *T. onolaus ida* Honrath. Finchafen, Mandated Territory.
(21) *T. hyperbolus hyperbolus* Kirsch. Mandated Territory.
(22) *T. dioptrica amitaba* Fruhstorfer. Waigeu.

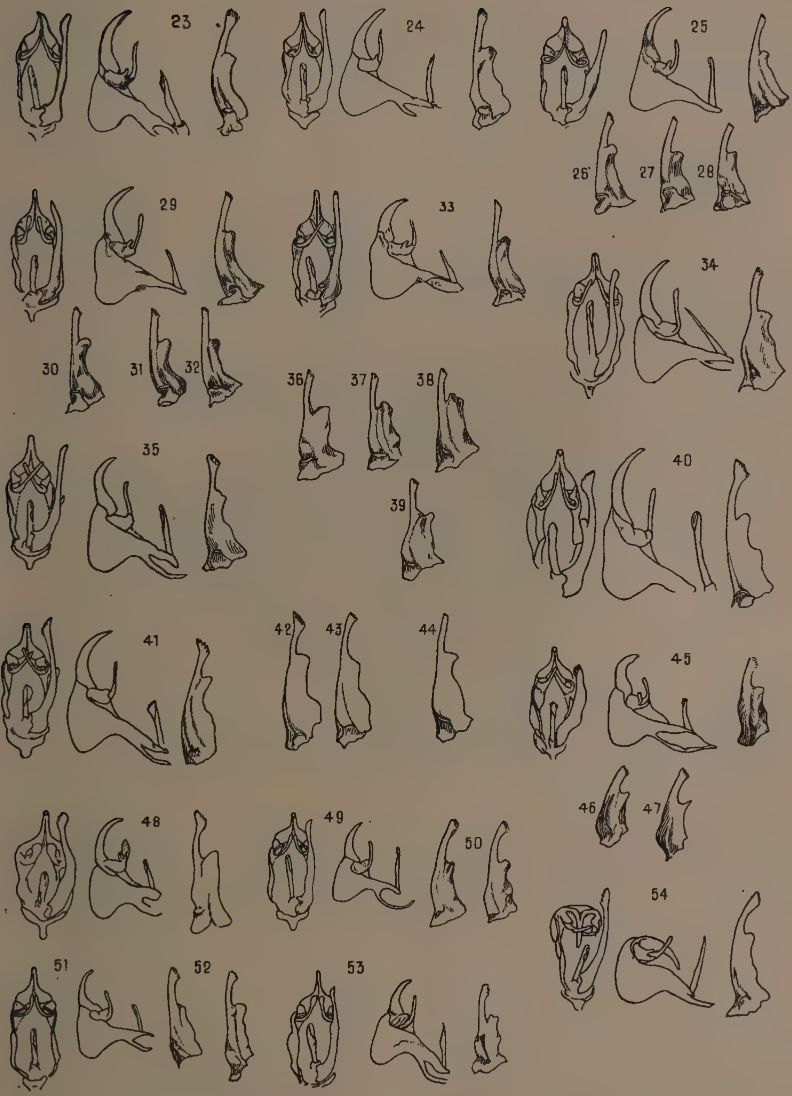


The genus *Tenaris*. Male Sex Armature.

PLATE VII.

Male Sex Armature (*continued*).

(23) *Tenaris myops rothschildi* G. H. Smith. Humboldt Bay.
(24) *T. myops wahnesi* Heller. Fr. Will. Hafen.
(25) *T. myops fergussonia* Fruhstorfer. Fergusson Island.
(26) *T. myops fergussonia* Fruhstorfer. Fergusson Island.
(27) *T. myops* f. *crus* Brooks. Fergusson Island.
(28) *T. myops miscus* Fruhstorfer. Goodenough Island.
(29 and 30) *T. myops kirschi* Staudinger. Port Moresby.
(31 and 32) *T. myops kirschi* Staudinger. Milne Bay.
(33) *T. myops kirschi* Staudinger. Hydrographer Mountains.
(34) *T. mailua mailua* G. H. Smith. Milne Bay.
(35) *T. cyclops acontius* Brooks. Wangaar.
(36 and 37) *T. mailua mailua* G. H. Smith. Milne Bay.
(38 and 39) *T. mailua rosseli* Fruhstorfer. Rossel Island.
(40) *T. cyclops cyclops* Staudinger. Fr. Will. Hafen.
(41) *T. chionides kuberyi* Stichel. ?.
(42) *T. chionides kuberyi* Stichel. Constantinhafen.
(43) *T. chionides chionides* Godman and Salvin. Upper Aroa River.
(44) *T. alocus* sp. n. Finchafen.
(45) *T. horsfieldii horsfieldii* Swainson. Java.
(46) *T. horsfieldii occulta* H. G. Smith. Kina Balu, Borneo.
(47) *T. horsfieldii plateni* Staudinger. Plawan.
(48) *T. butleri butleri* Oberthur. Brit. N. Guinea.
(49 and 50) *T. dimona dimona* Hewitson. Ceram.
(51) *T. dimona zaithe* Fruhstorfer. Eilanden River.
(52) *T. dimona zaithe* Fruhstorfer. Oetakwa River.
(53) *T. dimona aruensis* Brooks. Aru.
(54) *T. dimona* f. *microps* G. H. Smith. Humboldt Bay.



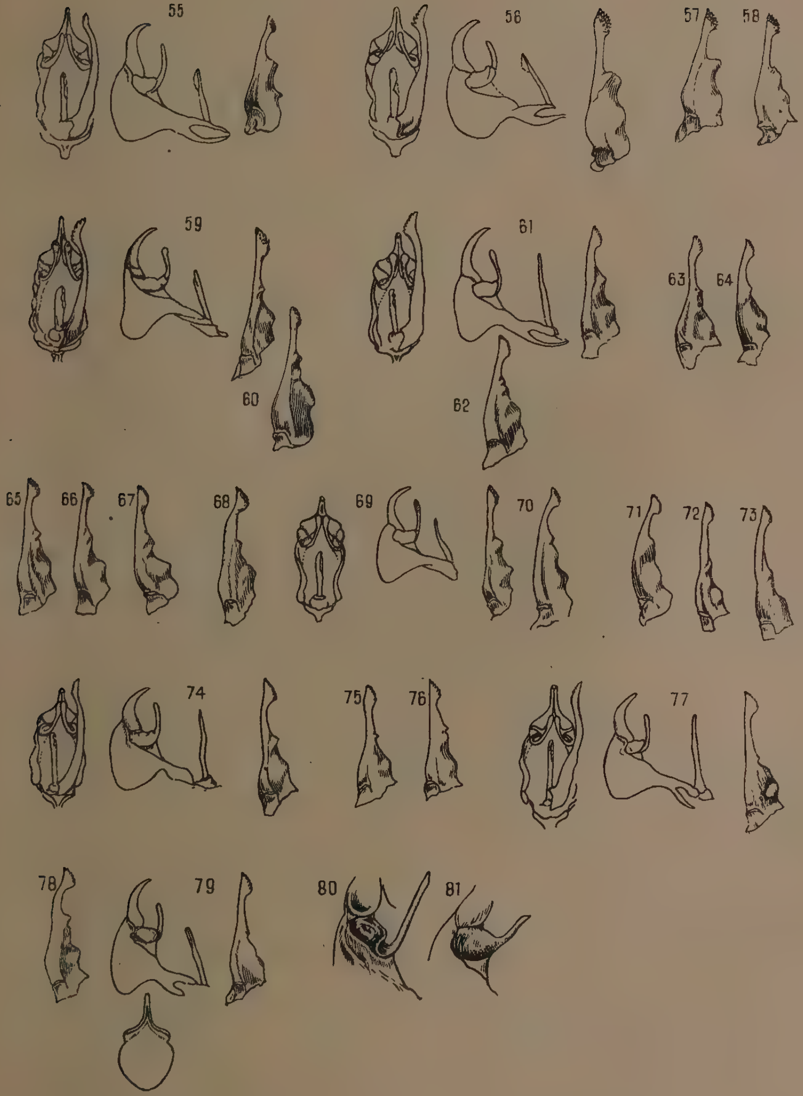
The genus *Tenaris*. Male Sex Armature.

PLATE VIII.

Male Sex Armature (*continued*).

(55) *Tenaris diana diana* Butler. Batjan.
(56–8) *T. urania urania* Linné. Amboina.
(59 and 60) *T. artemis artemis* v. Vollenhoven. Dorey.
(61 and 62) *T. artemis blandina* Fruhstorfer. Jobi.
(63 and 64) *T. artemis madu* Brooks. Schouten Island.
(65 and 66) *T. artemis zenada* f. *chares* f.n. Wangaar.
(67 and 68) *T. artemis zenada* Fruhstorfer. South Geelvink Bay.
(69–71) *T. artemis humboldti* Fruhstorfer. Humboldt Bay.
(72 and 73) *T. artemis staudingeri* Honrath. Mandated Territory.
(74) *T. artemis staudingeri* Honrath.
(75) *T. artemis jamesi* Butler. Milne Bay.
(76) *T. artemis electra* Fruhstorfer. Fergusson Island.
(77) *T. artemis barbata* Kirby. Rossel Island.
(78) *T. artemis* von Vollenhoven.
(79) *T. artemis* von Vollenhoven.
(80) Showing the "complex" base of the gnathos (*mailua*).
(81) Showing the "simple" base of the gnathos (*phorcas*).

PLATE VIII.



The genus *Tenaris.* Male Sex Armature.

Vol. 101. Part 7. Pp. 239–256, 17 figs. 30th November, 1950

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ON THE MORPHOLOGY AND FUNCTION OF THE ANTENNAE OF THE CENTRAL EUROPEAN HYDROPHILIDAE (COLEOPTERA).

By Jaroslav Hrbáček, F.R.E.S.

Manuscript received 25th May, 1949.
(Read 3rd May, 1950.)

With 17 Text-figures.

It has been known for about a hundred years (Nitzsch) that *Hydrous* (*Hydrophilus* of the early authors) has antennae which function as an auxiliary breathing apparatus. When the insect lies near the water surface the antennae form a funnel which leads the air to the ventral surface. The function of the antennae of the other genera of Hydrophilidae has not yet been studied in detail.

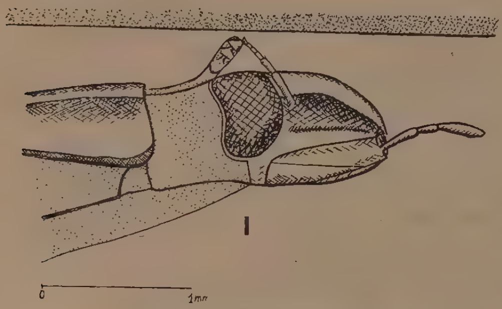
Various descriptions of the form of the antennae, dealing mainly with the number of segments in different genera, are included in the taxonomic diagnoses. Paasch, however, has already shown that the observations of earlier authors were not very reliable, even the number of segments not always being correctly given. The most detailed description of the antennae of the Central European genera is given in Ganglbauer's *Käfer von Mitteleuropa*, and Reitter (1909) gives figures of four types. The function of the antennae of *Hydrous* as a funnel connecting the air carried by the insect with the free atmosphere has been described by various authors, the most satisfactory accounts being those of Miall and Wesenberg-Lund. In order to simplify the task of reference illustrations of the most typical antennae are included in the present paper, the purpose of which is to give more or less detailed information on the form of those parts of the antennae concerned in this function.

Method.

The form and arrangement of parts has been studied on whole mounts, which have been made either from dry specimens or from specimens fixed in Carnoy's fluid. The antennae from dry specimens were boiled in potassium hydroxide solution and then mounted in glycerin-gelatine ; those of specimens fixed in Carnoy were usually stained with either borax or Mayer's carmine and then mounted in Canada-balsam. On these slides the muscles and some of the nervous filaments can be recognized clearly.

The investigation of the function of the antennae was carried out by direct observation of beetles in nature and also by observation of beetles kept in aquaria, where conditions similar to the original biotop were created as far as possible. The aquaria were kept in a glass-house. Specimens of the genus *Hydraena* from streams and brooks were kept in Petri-dishes, which were placed on a constantly moist filter-paper, so that the temperature never exceeded 19° C. The observations were carried out either with the naked eye or through a binocular microscope of Greenough type, placed on a tripod, which permitted not only horizontal and vertical movements to all sides without moving the object, but also observations from the oblique and horizontal.

Following these preliminary observations the beetle was fixed to a piece of wire by means of a rubber-like solution, which melted at about 35° C., then placed in a rectangular cell and observed approaching the surface. Two methods of making it do so were used. The beetle was either lifted towards the constant surface by means of a fine screw (used mainly when observed from above), or by sucking the water from the rectangular cell and thus lowering



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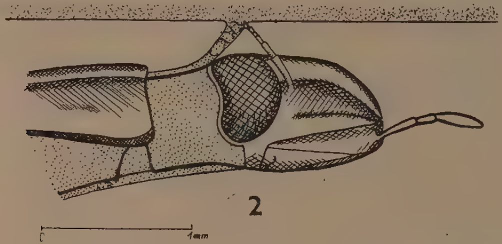

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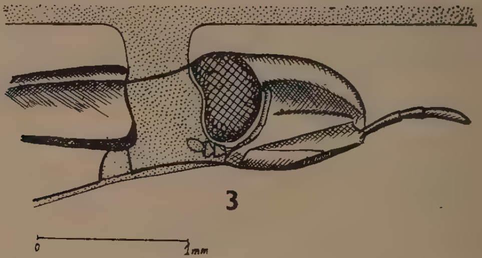

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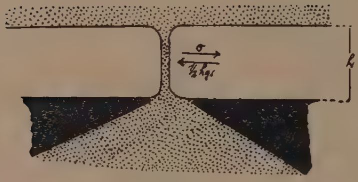

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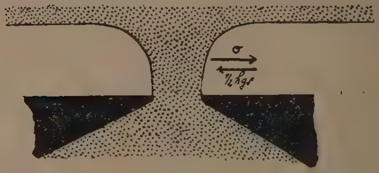

4b

the surface, while the beetle remained at the same spot (used when observed from the side). Observations were then repeated on beetles living free in nature or in an aquarium.

All drawings have been made from observations of specimens in a fixed position, but only after careful investigations had been made of the normal functions of free beetles.

The material used came mainly from Central Bohemia, and only a small part from Southern Bohemia.

Function of the Antennae in Breaking the Surface-film.

When a Hydrophilid beetle (e.g. *Helophorus aquaticus*) is fixed to a piece of wire in the above way and kept so that it cannot reach the water surface it is soon observed to put out its antennae in a peculiar manner (fig. 1). If the beetle is brought to the surface in the way described, at the moment when the top of the bent antennae touches the surface of the water (fig. 2) the film breaks and a broad funnel is formed (fig. 3). As this occurs instantaneously, direct observation does not provide an accurate explanation of the process. The formation of the narrow air-canal restricted to the dense hair of the last three or five joints may be observed by dropping a solution of sodium glycocholate in the cell where the beetle is being observed. This experiment also shows that the formation of the funnel can be partly prevented by a lowering of the surface tension of the water.

The role of the surface tension in the formation of the air-funnel can be approximately ascertained in the following way:

When the air-canal restricted to the unwetted hair of the antennal joints connecting the open air with the air-bubble is formed, two opposing forces are acting on it (fig. 4). One of these is the hydrostatic pressure which tends to eliminate the air-canal; the other is the surface tension, which tends to widen it, as it acts by binding the surface molecules so that when no other forces are acting the surface of liquids is always without any angle. As the surface tension is constant and as the hydrostatic pressure is proportionate to the height of the water-column, it is obvious that the water-column of a certain height exerts the same pressure on a given area as the surface tension, but in an opposite direction.

This height is important for further consideration, since when the water-column is shorter the surface tension is stronger than the hydrostatic pressure,

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FIGS. 1–4.—(1) *Helophorus aquaticus* L. held by force under the water level and trying in vain to reach the water surface with its antenna. (2) The same species having reached the surface with its bent antenna. (As the surface tension of the water was lowered by drops of natrium glycocholate solution only an air-canal restricted to the unwetted hairy tracts of three last joints has developed.) (3) The same species having reached the surface with its bent antenna, and by the action of the surface tension of the water an air-funnel has been formed through which the beetle takes in fresh air. (4) Diagram showing the forces which act on the air-canal primarily formed. σ is the surface tension; $\frac{1}{2}$ Hg is the hydrostatic pressure of the water-column, the height of which is h. Black areas represent sections through the body near the air-funnel. The upper side is readily wetted by water, whereas the lower side is protected with hairy tracts which cannot be wetted by water. A, The hydrostatic pressure is stronger than the surface-tension of the water, so that the air-canal formed by the hydrofugal hairy tracts of the antennal joints remains unchanged. B, The hydrostatic pressure is weaker than the surface tension, so that an air-funnel is formed.

and the air-canal primarily formed by the hydrofugal hairy tracts broadens to an air-funnel. This may be easily proved experimentally by dropping different amounts of sodium glycocholate into the experimental cell. The greater the amount of sodium glycocholate and the lower therefore the surface tension of the water, the shorter is the length of the air-funnel.

The greatest possible length of the air-funnel formed by different species (*Hydrobius fuscipes*, *Helochares griseus*, and *Enochrus testaceus* and *quadripunctatus*) directly measured varied between 1 and 1·5 mm., and thus agreed well with the theoretical conclusion. The wide variation of results is undoubtedly partly due to difficulties in reading and partly to pollution with excrements, etc., which lowers the surface tension.

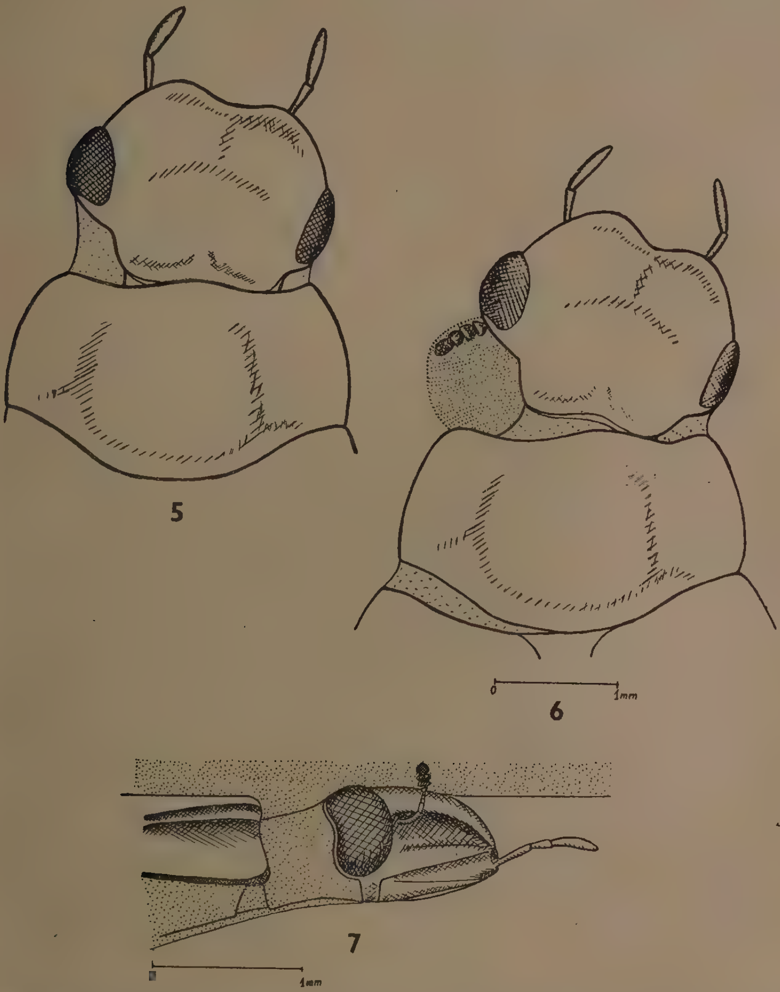
Compared with *Aphelocheirus*, whose hydrofugal hairy tracts have been carefully studied by Thorpe and Crisp, the hydrofugal properties of the hairy tracts of the antennae of Hydrophilidae are not nearly so perfectly developed. When either a whole Hydrophilid beetle or only a cut-off antenna is placed in a receptacle containing water from which the air has been partially removed, all air retained in the hairy tracts disappears after one, two or three hours. It must be remembered that the air-bubble carried in the abdominal side of the body is free, i.e. not held by hairs, and that the hairs of the antennae are therefore in contact with the water only for a relatively very short time.

The genae and ventral parts of the head, as well as the ventral parts of the pronotum, are also provided with hydrofugal hairy tracts. When the beetle bends its antennae it stretches its head somewhat forward so that an angle between the back part of the head and the frontal part of the prothorax is formed (fig. 5). As the sides of this angle are also provided with unwetted hairy tracts, the water, owing to the surface tension, cannot lie close to the circumference of the body. Thus it is possible to observe from above how a bubble of a triangular shape is formed. When the antenna is fully bent the last joint is anchored in this bubble. Moreover the air-funnel forming this triangle serves as the basis of the funnel.

When the funnel has been formed the antenna either returns to its position under the eye (fig. 3), or the last unwetted joints are placed round the outer margin of the funnel (fig. 6). In this manner it is protected against small ripples.

The transition of the antenna from the position shown in fig. 1 or 2 to the position shown in fig. 3 or 6 is almost instantaneous. Nevertheless, I am of the opinion, as the result of observations on *Helophorus aquaticus* in a 2 per cent. gelatinous solution, that the transition from the position shown in fig. 1 and 2 to the position shown in fig. 3 is gradual and smooth, so that the sharp bending of the antenna ceases as soon as it touches the water surface, and the gently curved antenna is laid round the eye, directly in the position shown in fig. 3. When the air-canal has been formed the antenna is sometimes seen erected above the head as it is when the beetle is walking on dry land (fig. 7). On the basis of numerous observations it can be taken as established that this occurs only when the back of the head of the beetle is somewhat raised above the water surface. This causes an unusually broad funnel to develop, and therefore the side wall of the funnel against which the antenna leans in passing into the position underneath the eyes or round the outer margin of the funnel is absent. The antenna is then held erect as when the beetle walks on dry land.

Observations of attempts of the beetle to breathe while being kept under the surface by force show that it bends its antenna over the head. The beetle first lifts the antennae, and thus the unwetted joints are withdrawn from the bubble by the muscular movement. This action of the muscles of the scape (first part) turns the wetted joints towards the surface. The unwetted three



Figs. 5–7.—(5) *Spercheus emarginatus* Schall. The head projecting slightly so that a triangular air-bubble is formed from which the antennae are bent. (6) The same species taking in fresh air at the water surface. (7) *Helophorus aquaticus* raised somewhat above the water level so that a broad funnel has developed and the antenna is erected in front of the eye.

or five last joints are drawn out from the flattish air-bubble in the angle between the head and margin of the prothorax as noted above. The surface tension acts as a force, which pulls the unwetted joints back to the air-bubble. Since the conical joint permits a quite independent movement of the last unwetted parts, a bending results, as may be seen from the drawing (fig. 8).

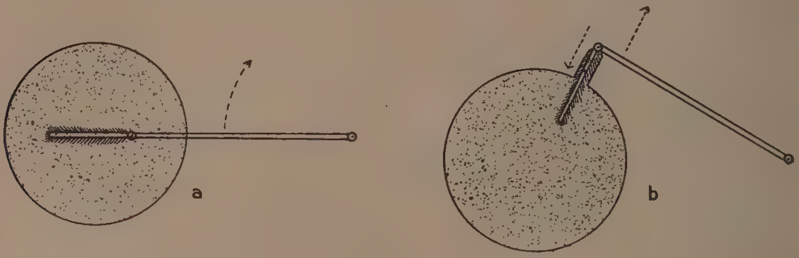


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FIG. 8A and B.—Diagram showing the forces which bend the antenna.

The Ecological Advantage of the Auxiliary Function of the Antennae.

When considering the ecological importance of the ability to take in fresh air when the air-bubble of the beetle is about 1 mm. below the water surface instead of at the water surface, it must be remembered that the dorsal part of the body, which is not provided with hydrofugal hairs, is more or less concave, so that a partial emergence of this part is needed for the air-bubble to come into direct contact with the air. In order that part of the body may emerge some extra force has to be present, and, as the Hydrophilid beetles are for the greater part only poor swimmers, a solid support is needed. A beetle blown by the wind away from the littoral zone to deeper water would perish in most cases, as it is incapable of lifting its air-bubble to the water level. Hydrophilid beetles kept in water so that they cannot renew their air die in 4–6 hours under normal conditions. A detailed communication on this subject will be published later.

Many species of Hydrophilid beetles under natural conditions walk on the bottom, which they have reached by descending some leaf or stem, and when they are in need of fresh air they simply leave the support. Since their weight is overcompensated by the air-bubble the water brings them to the surface, where they make use of the ability to take in air under these conditions with their antennae. Experiments have shown that, with the exception of the genera *Hydraena* (ex parte), *Helophorus* and *Berosus*, all species of Hydrophilid beetles died when kept with amputated antennae in water in a glass container arranged so that they could not emerge above the water surface. In this connection is should be mentioned that specimens with whole antennae also, after being kept for some weeks in the laboratory, had difficulty in obtaining fresh air at the open surface if no support was present in the neighbourhood of the water surface. This effect of captivity is most striking in *Anacaena* and *Hydrobius*.

The Relation between the Form and Function of the Antennae in Different Genera.

The antennae of the genera considered to be the most primitive (i.e., in Central Europe, *Ochthebius* Leach (species examined : *O. minimus* Fabricius = *impressus* Marsh., *O. pusillus* Steph.), *Hydraena* Kugel. (*H palustris* Er., *H. riparia* Kugel., *H. gracilis* Germ., *H. emarginata* Rey subsp. *saga* d'Orch., *H. nigrita* Germ.) and *Limnebius* Leach (*L. crinifer* Rey, *L. truncatellus* Thunb., *L. papposus* Muls.)) are quite similar in their basic features (fig. 9*a*). Their first and second segments are long and curved, the next two joints are smaller, the fourth is conical but quite unsymmetrically shaped, and the five last joints are uniformly covered with very fine, short, close-set hairs. Only the five last joints lie in the flattish bubble of air retained by the hairy tracts on the upperside.

When the air carried by the beetle has been connected with the free air, the tip of the antenna protrudes somewhat above the surface of the water. This is because the antenna does not follow exactly the lower margin of the eye, but is situated somewhat higher, as shown in fig. 3. When studying species of the genus *Limnebius* it was sometimes seen that when the connection of the air-bubble had been established the antenna lay in a circle round the lower margin of the eye, but almost horizontally, and the last joints then followed the outer contour of the air-funnel. This position of the antennae resembles that shown in fig. 6. The chief difference lies in the fact that in *Limnebius* the whole outer margin is followed by the antennal joints. In this genus, however, this position of the antennae in the air-funnel is rather unusual and occurs only under special conditions, when the funnel is relatively broad. I was not able to observe the raising of the antennae above the water surface prior to the formation of the funnel between the air-bubble of the beetle and the free air (as Hase has observed and figured it). In specimens of *Hydraena emarginata* Rey subsp. *saga* d'Orch. I observed that the antenna does not usually participate in the forming of the funnel, but that the beetle breaks the surface film of the water by pressing the back part of the head and the front part of the thorax slightly above the surface. Then the head is erected slightly, and the surface film broken between the head and the thorax by a small cleft through which the air can reach the stigmata.

The antennae of the genus *Helophorus* F. (fig. 9*d*) (*H. aquaticus* L., *H. flavipes* F. = *viridicollis* Steph., *H. nubilus* F., *H. guttulus* Motsch. subsp. *brevipalpis* Bedel, *H. dorsalis* Marsh. = *quadrisignatus* Bach., *H. granularis* L.) have several times been discussed in literature, as the number of joints is not constant (Paasch, d'Orchymont, 1929). The number of segments (8–9) not only varies with different species, but also within a given species, and specimens have been found in which one antenna had 9 and the other 8 segments. Only the three terminal ones are provided with fine hydrofugal hairs. The conical joint is only slightly assymetrical.

The position and the form of the air-funnel, through which the air carried by the beetle and the atmospheric air communicate, have already been observed by d'Orchymont (1916 and 1933), who correctly recognized that this genus differs from its allies in that the whole back part of the head normally participates in the formation of the funnel (fig. 10). One might assume from d'Orchymont's remarks that the formation of the funnel in the genus *Helophorus* F. is quite similar to that which has already been mentioned above in *Hydraena* *emarginata* Rey subsp. *saga* d'Orch., but this is not so in the case of specimens below the water surface. Nevertheless, specimens deprived of their antennae can break the water-film in the same manner as the last mentioned species. When the beetle is striking the water surface with the side of the head only one antenna is used for breaking the surface-film, and the resulting air-funnel is more or less restricted.

The specimens examined of the genus *Helophorus* F. differ from nearly all other beetles studied (species of the genus *Laccobius* being sometimes an exception) in that they bend both antennae at the same time, and the air-funnel is extended to the whole back part of the head.

The antennae of specimens examined of the genus *Hydrochus* Leach (fig. 9*b*) (*H. elongatus* Schall.) are somewhat differently shaped. The fourth part (the part in front of the three last joints with hydrofugal hairs) is not conical, as is usual, but is provided with a recurvate horn. When a species of this genus approaches the surface film, the whole antenna is bent in a peculiar manner in front of the eye, as may be seen in fig. 11. The three last unwetted joints are extracted from the air-bubble in the cavity near the eye (fig. 12). The recurved horn fixes them in a convenient position.

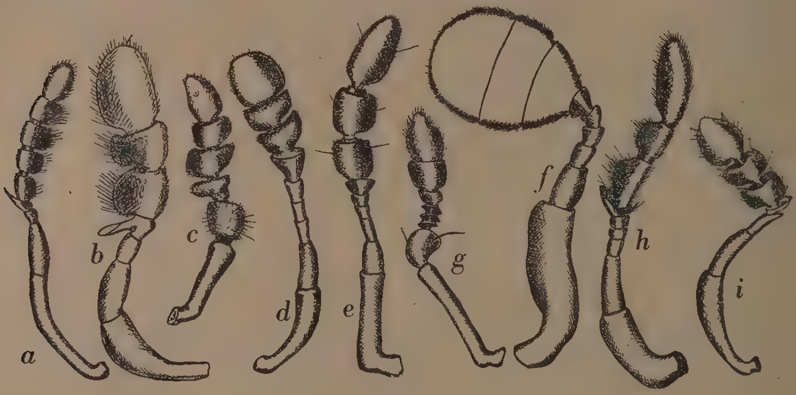

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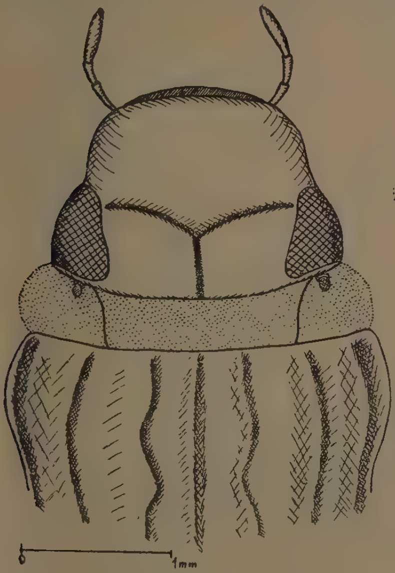
FIG. 9.—Antennae of *a*, *Ochthebius minimus* F.; *b*, *Hydrochus elongatus* Schall.; *c*, *Spercheus emarginatus* Schall.; *d*, *Helophorus aquaticus* L.; *e*, *Coelostoma orbiculare* F.; *f*, *Chaetarthria seminulum* Herbst.; *h*, *Helochares obscurus* Müll.; *i*, *Berosus luridus* L.

The genus *Spercheus* Kugel. (*S. emarginatus* Schall.) has developed a very characteristic antenna (fig. 9*c*). The first part is long and uncurped, and the second part is short and covered both with fine short, close-set hairs and long projecting bristles. The other joints are covered nearly exclusively with fine hairs, and have only a few long bristles.

The antenna is bent in a similar way (but not so sharply) to that shown in fig. 1. The funnel established, the terminal joints follow the outer margin of the funnel, as shown in fig. 6. The size of the funnel varies a little, not only with the distance between the beetle and the water surface, but also in individual cases. In the case of a deep funnel the joints of the antennae are generally farther apart and the antenna is gently curved.

Of the subfamily SPHAERIDIINAE I examined the following genera: *Coelostoma* Brullé, *Cercyon* Leach, *Sphaeridium* Fabricius and *Cryptopleurum* Muls. The antennae of the genera *Coelostoma* (*C. orbiculare* Fabricius) (fig. 9*e*) and *Cercyon* (*C. impressus* Sturm., *C. ustulatus* Preyssl., *C. lateralis* Marsh., *C. unipunctatus* L., *C. quisquilius* L.) are like those of the genus *Helophorus*, only the first joint being uncurved, and the part in front of the unwetted joints symmetrical and broadly conical. Species which live in or near water bend the



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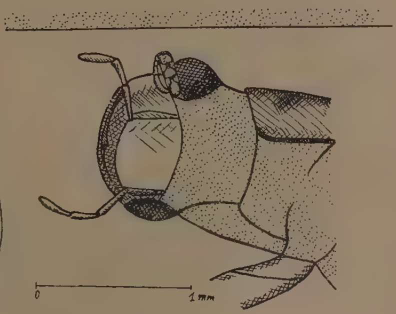

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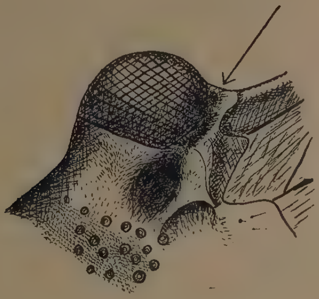

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FIGS. 10–12.—(10) *Helophorus aquaticus* L. taking in fresh air at the water surface (seen from above). (11) *Hydrochus elongatus* Schall. bending its antenna and trying to reach the water surface. (12) *Hydrochus elongatus*: Lower part of the head in the vicinity of the eye. (In water the antenna is held in the direction indicated. The inarticulation of the antenna is shown by a black area in front of the margin of the eye.)

antennae in the way described above, but in a gentle curve and not so high above the head. The basal joint of the antennae of the genera *Sphaeridium* (*S. bipustulatum* F., *S. scarabeoides* L.) and *Cryptopleurum* (*C. minutum* F., *C. crenatum* Panz.) is more or less S-shaped. The three last joints are flattened. The antennae of the genus *Cryptopleurum* (fig. 9*f*) are the most characteristic in this respect. When kept in water the beetle uses its antennae to break the surface film by pressing them towards the thin water-film when the beetle is somewhat above the water surface.

As these species generally live in excrement, I also examined other species of the genera (*Onthophagus* Latr. and *Aphodius* Ill.) living in the same habitat, and found their behaviour in this respect very similar to that of coprophilous species of SPHAERIDIINAE.

Specimens were kept in a glass container with shallow water, in which submerged plants, dry leaves and other detritus, enabled the beetles to climb easily towards the water surface and to some extent also above it. Observing *Ontophagus ovatus* L. one very often sees that it takes air at the water surface in a way quite similar to that of the genus *Helophorus* F. The head is slightly raised, and behind the eyes two funnels can easily be observed, on the base of which the tip of the antennae can be seen. This case is, however, rather exceptional, as the air-bubble on the ventral part of the body of *Onthophagus* can hardly exist longer than 12–24 hours, neither the hairs nor the general shape of the body being able to retain the air-bubble for a longer period. The genus *Aphodius* is better adapted in this respect. In this genus, however, the thick wall behind the eyes does not permit the formation of an air-funnel, so that the beetle need not put the frontal part of its head above the water surface before breaking the surface film. When an *Aphodius* is observed from the side, it is easily seen that from time to time its antennae are pressed against the surface film of the air-bubble. When the beetle comes close to the surface film the antennae are pressed against the surface film so regularly as to give an impression of drumming. As the force which presses the antenna towards the surface film is weak, it can break only a thin pellicle of water, i.e. the antennae can be successfully used only when the beetle is more or less above the water surface. These observations on coprophagous beetles were made on beetles having freedom of movement. Beetles attached to a wire never behave in this way.

The antennae of the genera *Anacaena* Thoms. (*A. limbata* F., *A. globulus* Payk.), *Hydrobius* Leach (*H. fuscipes* L.), *Crenitis* Bedel (*C. punctatostriata* Lentz.) and *Limnoxenus* Motsch. (L. *niger* Zschach) resemble those found in *Coelostoma*, and hardly any difference could be ascertained in their function. When the air-funnel is formed the last joints are usually placed on the outer margin of the air-funnel in a way similar to that shown in fig. 6. This position of the last joint after the formation of the funnel may be observed also in the genus *Coelostoma*. However, in this genus it is often observed that the last joints are placed round the lower margin of the eye, as in fig. 3.

The antennae of the genera *Helochares* (*H. obscurus* Müll. = *griseus* F.) (fig. 9*h*), *Enochrus* Thoms. (*E. testaceus* Fabr., *E. quadripunctatus* Herbst, *E. minutus* Fabr.), and *Cymbiodyta* Bedel (*C. marginella* Fabr.) are similar to one another, and differ from the antennae of the genera previously mentioned by the basal joint being more curved and the conical joint being asymmetrical.

The antennae of the genus *Laccobius* (*L. minvtus* L., *L. striatulus* Fabr. = *nigriceps* Thoms., *L. bipunctatus* F. = *alutaceus* Thoms.) differ from those of the preceding genera only in the fact that the joint before the asymmetrical, conical part has also a conical but more symmetrical shape. It is worth mentioning that *Laccobius* is able to bend its antennae fairly high above its head, and when imprisoned under water it bends both antennae together, though when it reaches the surface film it forms only one air-funnel.

The antennae of the genus *Hydrophilus* (*H. caraboides* L.) are very similar to the well-known antennae of the great water-beetle *Hydrous*, except that the concavity of the three terminal joints is not so well developed. The function of the antennae is the same as in the preceding genera.

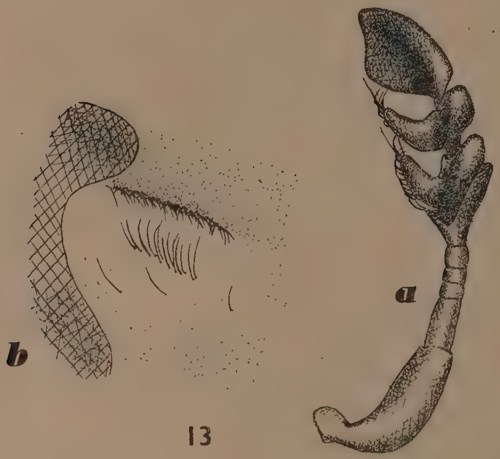
In the genus *Berosus* (fig. 9*i*) (*B. luridus* L., *B. spinosus* Stev.) the three unwetted joints of the antennae are situated at right angles to the other joints. The beetle takes in air very rapidly, and this intake of air can hardly be prolonged to a maximum of two seconds by an artificial prolongation of the time of submergence. When kept attached to a wire for a longer time in the water it can only very exceptionally be seen to bend its antennae ; moreover, in these exceptional cases it bends the antennae very little. This genus is also able to break the surface film on the open water without the aid of the antennae. Deprived of its antennae it swims towards the surface film and breaks the surface with the unwetted part of its head (especially the genae). Blunck and Speyer observed similar behaviour in an *Hydrous* deprived of its antennae. I was unable to confirm this observation, although 12 specimens of this genus were examined.

From the above it may be gathered that the auxiliary function of the antennae is far better developed in species which live chiefly in water than in those which live preferably or exclusively in decayed matter or excrements.

The effect of this function on the form of the antennal joints can be seen mainly on the scape and on the joint preceding the joints provided with hairy tracts. The scape (first joint) is hooked in species in which the auxiliary function of the antennae is well developed. In the same species the part preceding the joints provided with hairy tracts is asymmetrically shaped in a manner which permits a sharp bending of the antennae. On the other hand, in species which live under and in decayed matter the scape is either uncurved or slightly S-shaped. The conical part in front of the joints with hairy tracts is symmetrical, and permits only an imperfect bending of the antennae. The three last joints are more or less enlarged. All these features can easily be understood if we assume that in these beetles the antennae function more or less exclusively as feelers. It is noticeable in cases where the scape is S-shaped that the whole antenna assumes the form of a broad V when the beetle is walking freely in the open. V-shaped antennae are typical for those species in which they serve principally as feelers (*Lucanus*, *Melolontha*, etc.).

The Special Modification of the Form and Function of the Antennae of the Great Water-Beetle Hydrous.

The antenna of the great water-beetle *Hydrous* (fig. 13*b*) (*H. aterrimus* Eschsch., *H. piceus* L.) is characterized by the shape of its last three joints, which are so curved and dilated as together to form a funnel or, perhaps better, a half-funnel. When the beetle takes in fresh air at the water-surface it does



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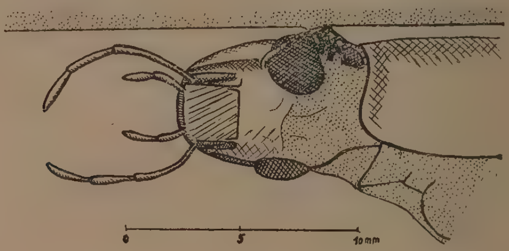

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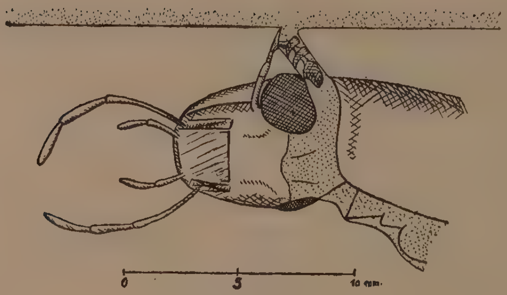

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Figs. 13–15.—(13) *Hydrous aterrimus* Eschsch. *a*, Antenna ; *b*, genae with two rows of long bristles. (14) The same species breathing at the water surface. (The antenna is pressed against the space between the two rows of bristles.) (15) The same species with fully bent antenna forming an air-funnel longer than 1·5 mm.

so through this funnel. As Wesenberg-Lund (1915) showed, two rows of long bristles (fig. 13*b*) are situated on the genae of *Hydrous*.[1] These bristles usually play an important part in the formation of the air-funnel, as the open part of the antennal funnel is pressed against the space between these two rows (fig. 14). The funnel can also perform its function without help of these bristles. This can be shown by allowing the beetle to reach the surface only with fully bent antennae (fig. 15). The figure of Nitzsch (1811) also demonstrates this point.

As shown above, the maximum length of the funnel, which is formed by the surface tension of the water alone, is about 1·5 mm. As the total length of the three last unwetted joints is greater, it agrees well with the theoretical conclusions that the air-funnel is formed in *Hydrous* in a different way from that of the preceding genera.

Under normal conditions the first way of forming the air-funnel is more generally used. The fact that the antenna itself is able to develop an air-funnel was experimentally established by Przibram, but he did not give an explanation of his experiment. He found that when the beetle was prevented from approaching close to the surface by a metal network, which had been stretched at a distance of about 1 mm. from the water surface, it was still able to take in the necessary air. The beetle deprived of its antennae was unable to do so and perished in a short time.

In my own experiments I put a glass container of about 2 litres capacity closed with a convenient metal network (the mesh of which was about 4 mm. in diameter) in a large dish of about 5 litres capacity. In the inner, closed container 4–6 specimens of *Hydrous aterrimus* were kept along with some aquatic plants (*Helodea*, *Myriophyllum*, *Ceratophyllum*). In regulating the water-level in the outer container, the distance between the network and the surface film could be changed easily. I began with observations of the normal breathing of the beetle, when the water surface was at the same level as the network. After an hour's observation the water level was raised so that the distance was 1 mm., and every hour the distance was increased by 1 mm. Up to a distance of not more than 2 mm. all examined specimens had taken in air without any injury, although it took sometimes some seconds before they succeeded. When the distance was raised to 3 mm., some specimens, especially females, were unable to form the air-funnel. When the distance was as great as 4 mm. 3 of 14 specimens examined were still able to live under these conditions; others were not successful in taking in air as often as they needed, and after a period of raised vitality they became apathetic. When the surface was raised to 5 mm. distance no specimen succeeded in taking in air. During the period of increased activity the beetle often climbed the network, the venter turned to the upper side, and also in this position it bent its antennae above its head, although the antennae were now directed away from the water surface. This indicates that the position of venter upwards, so common in other genera of HYDROPHILIDAE (*Anacaena*, *Helophorus*, *Hydrobius*, *Spercheus*, *Limnebius*), is unusual in this case.

During the same experiment attention was also paid to the in- and expiratory movements of the abdomen. The time between an in- and outbreathing was generally longer when the length of the air-funnel rose. In a particular case one specimen made six respiratory movements in 8 seconds after a submersion of about 12 minutes, when the network was in the water level, and the same number of respiratory movements were carried out in 16 seconds after a submergence of 14 minutes and when the network was at a distance of 2 mm. from the surface film.

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[1] The genae of other Central European Hydrophilid beetles have irregular, more or less dense bristles.

In all other Hydrophilid-beetles we have seen that the antenna was bent only until the moment of formation of the air-funnel. Here the antenna remains in its bent position. When the funnel is formed principally by the antenna itself, it is the surface tension and hydrostatic pressure which fix the antenna in its bent position. When the air-funnel is formed on one side by the space between both bristle-rows on the genae, it is primarily the hydrostatic pressure which presses the last unwetted joints against the bristle-rows, and thus helps to fix them. On the other hand, the wetted conical part of the antenna provided with long wetted bristles, and the long projecting wetted bristles present on all joints provided with short unwetted hairy tracts, especially on the first one, make it impossible for the air-funnel to widen even when the length of the funnel becomes shorter than the critical distance of 1·5 mm., and a greater funnel should develop. The long wetted bristles are anchored in the surrounding water, which adheres to them, and in this way the surface tension which should widen the funnel is compensated by the adhesion.[1] This is of ecological importance. When the beetle takes in air on the free water surface it becomes lighter and the air-funnel becomes finally shorter than 1·5 mm. If a broader funnel should develop the antenna could no longer be held in a bent position, as the hydrostatic pressure, which helps to fix it in its bent position, would cease to act and an erection of the antenna would occur. In the expiration following the inspiration the beetle becomes relatively heavier and is submerged somewhat deeper. If the funnel were longer than the critical distance of 1·5 mm. (or more as needed for the hysteresis) a broad funnel would be destroyed. For the next inspiration following immediately a new funnel would be formed. It is noteworthy that *Hydrous* renews its air by a series of 3–6 in-and expirations.

The beetle, on climbing on to water plants, sometimes approaches too near the surface, and the air-funnel widens, as in other Hydrophilid beetles. Then the antenna cannot be kept in the bent position and is erected above the water surface. This position has been described by some authors (the first of whom seems to have been Fricken) as the normal position, which is erroneous. The erection of the antennae is here of the same nature as was mentioned in the description of the function of the antennae of other Hydrophilidae. The erected antenna cannot be bent unless the beetle is wholly submerged.

The Effect of the Shape of the Back Part of the Head on the Form and Function of the Antennae.

When the shape of the head in *Hydraena*, *Helophorus* and *Anacaena* (fig. 16) is considered, and it is remembered that in nearly all genera of Hydrophilidae (except *Hydrochus*) the antenna is bent so as to raise the unwetted joints behind the eye, although they are inarticulated in front, it is readily understood why the antennae in HYDRAENINAE-LIMNEBIINAE are relatively longer than, for instance, those of *Anacaena* (fig. 17). Once the funnel is formed these longer antennae can only rarely follow its outer margin. Again, in the genus *Berosus* the eyes project slightly from the contour of the head. The antennae once abbreviated and " accustomed " to follow the outer margin (which certainly protects the air-funnel against narrow ripples) become permanently bent at a right angle, and can therefore only to a small extent be bent above the head when the insect approaches the water surface. As this beetle is the strongest swimmer among the HYDROPHILIDAE, it is not inconvenienced by this. The fact that the projecting eye requires a long antennae whereas the protection of the outer margin of the air-funnel needs only a short antenna, can only be met by bending the shorter antenna in front of the eye. This feature is found in *Hydrochus*, but has the disadvantage, on the one hand, that the eye near where the funnel is formed is prevented from functioning, and, on the other hand, that the basis of the air-funnel is not very solid, as the eye is not provided with dense hairs which cannot be wetted by water.

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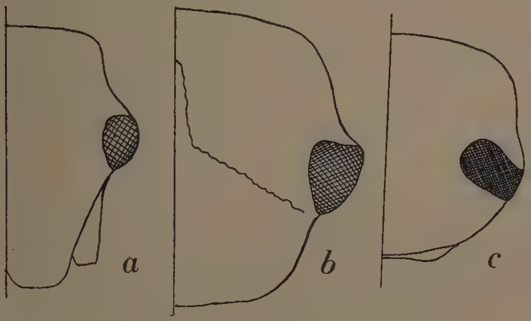
[1] In other species also longer bristles are sometimes found on the last antennal joints, but they are unwetted with water, most of them being sensillae.



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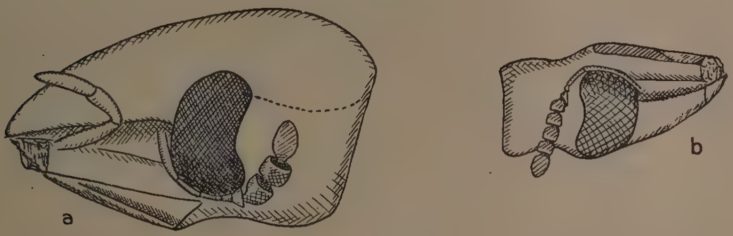

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FIGS. 16, 17.—(16) Contours of heads of the genera : *a*, *Hydraena* ; *b*, *Helophorus* ; *c*, *Anacaena*. (17) The relative length of the antenna in the genera : *a*, *Anacaena* ; *b*, *Ochthebius*. (Dotted line indicates the upper margin of dense unwetted hairy tracts on the head of *Anacaena*.)

The Relative Length of Unwetted Joints.

If the relative length of the unwetted joints of the genus *Helophorus* and of the genera *Anacaena* and *Helochares* are compared it is easily seen that in the last two genera the unwetted joints are relatively longer than in *Helophorus*. This can be understood if it is remembered that in both these genera the back part of the head is more convex than in *Helophorus*, and that the cranial parts above the genae are not provided with unwetted hairy tracts as in *Helophorus* (fig. 16). In *Anacaena* and *Helochares*, the dorsal parts of the body being exactly in the surface level, the air-canal developed by the hairy tracts of the antennae must be relatively longer than in *Helophorus*. From the relative shortness of the parts provided with unwetted hairy tracts in this genus it may be concluded that the chief purpose of the auxiliary function of the antennae is to enable the beetle to take in fresh air when not wholly submerged, and not to enable it to take in air while being deeply submerged, for which purpose the length of 1·5 mm. is too short to be of any great assistance. The air-funnel in *Hydrous*, which is longer than 1·5 mm., enables the beetle to take in air when wholly submerged.

By comparing the relative length of the antennae of the genera *Anacaena* and *Helochares* it will easily be seen that the unwetted joints are relatively shorter in the former genus. This is in agreement with the fact that in *Anacaena* the antenna is bent only to a limited extent above the head. The relative length in coprophilous SPHAERIDIINAE is still smaller. From this point of view the relative shortness of the unwetted joints in the genus *Berosus* can also be easily understood, as, as previously shown, the antenna is bent only to a very limited extent. It is generally true that all unwetted joints together are relatively longer in aquatic species (with the exception of the genera *Helophorus* and *Berosus*, as indicated above) than in species living preferably on dry land.

Phylogenetical Consideration of the Development of the Auxiliary Function of the Antennae.

In studying the behaviour of coprophagous Lamellicorniid beetles in water it has been found that the auxiliary function of the antennae in HYDROPHILIDAE is not so extraordinary as might have been expected. For its full development the presence of dense hairy tracts which permit the formation of the ventral air-bubble on the ventral part of the body is of fundamental importance. The basal function of the antennae is to help to break the thin pellicle of water when the beetle emerges slightly above the surface. The antennae in ancestors of present-day HYDROPHILIDAE being long (according to d'Orchymont, 1913 and 1916—11 joints), the force with which the tip of the antennae was pressed against the water pellicle was insufficient to break larger pellicles of water, When a greater force was used the antenna was bent and the surface film broken, not by the tip of the antennae, but by the middle of the curved antenna. In this way a greater force can be exerted, and when the part in the middle of the antennae gains an asymmetrical form, which makes possible a sharp bending in the middle of the antenna, the surface tension is utilized in forming the air-funnel and the antenna acquired the form which we know, for instance, in the genus *Hydraena*.

If the similarities and dissimilarities in the form and function of the antennae are compared with the taxonomic relationship of the genera in question, we may say that considerable agreement is shown, as different subfamilies are characterized by peculiarities in the form of their antennae. This agreement is to a large extent associated with the different form of the head capsule in different subfamilies, as the shape of the back part of the head has a great influence on the form of the antennae, as shown in a previous section. The phylogenetical significance of the morphology of the head capsule was demonstrated by d'Orchymont (1916). The antennae of the genera *Hydraena*, *Ochthebius*, *Limnebius*, *Hydrochus* and especially *Spercheus* can hardly be considered as links between the antennae of the ancestors of the family and the antennae of the most advanced genera of to-day. They are better considered as the last members of another evolutionary series. The retention of archaic features can sometimes be explained by their possessing little possibility for development in the direction of evolutionary tendencies of other groups, e.g. the long antennae in HYDRAENINAE.

ACKNOWLEDGMENTS.

It is my pleasant duty to express my deepest thanks to Professor Dr. J. Komárek, Director of the Department of Systematic Zoology in the Charles University, Prague. Professor Komárek not only helped me greatly by his suggestions and advice, but also enabled me to carry out this work by granting facilities in his Department, and thus enabled me to devote myself wholly to this work. Further, I wish to express my thanks to Docent Dr. K. Wenig for the interest he has shown, and to Dr. A. Lengerová-Kučerová for her help in the drawing of some of the figures.

I am greatly indebted for their real criticisms to Dr. W. H. Thorpe, of the Zoological Laboratory, Cambridge, and to Dr. D. J. Crisp, of Imperial Chemical Industries.

SUMMARY.

1. The antennae of the beetles of the family HYDROPHILIDAE are used as auxiliary organs for connecting the bubble carried on the underside with the free air.

2. This connection is first restricted to the unwetted hairy tracts of the last antennal joints. By the action of the surface tension up to a depth of about 1·5 mm. a broader air-funnel is formed, through which the beetle renews its air.

3. In aquatic forms this auxiliary function predominates over the function of the antennae as feelers, whereas in terrestrial (coprophilous, etc.) forms it is of secondary importance.

4. The form of the joint in front of the joints provided with unwetted hairy tracts and the form of the scape (first antennal joint) are determined by the function of the antennae.

5. The unwetted last joints being longer than 1·5 mm. in the great water-beetle, they are so shaped as to form the air-funnel alone.

6. The total length of the antenna is affected by the form of the back of the head capsule of the beetle, and the relative length of the unwetted joints by the convexity of the dorsal part of the body.

7. In terrestrial forms the unwetted joints together are relatively shorter than in aquatic forms. The genera *Berosus* and *Helophorus* are an exception which can be explained by other peculiarities in the function of the antennae in these genera.

8. The morphological relationship of the antennae of different genera agrees well with the taxonomic relationship of these genera.

9. The auxiliary function of the antennae is to be found in a primitive form also in some coprophilous Lamellicornia.

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A SURVEY OF THE CHLOROCYPHIDAE (ODONATA: ZYGOPTERA), WITH DIAGNOSES OF PROPOSED NEW GENERA, AND DESCRIPTION OF A NEW GEOGRAPHICAL SUBSPECIES.

By F. F. Laidlaw.

Manuscript received 24th March, 1950.
(Read 3rd May, 1950.)

With 8 Text-figs.

Introduction.

Just over fifty years ago I collected examples of this family on the upper waters of the Kelantan river, and over a small mountain stream at the foot of the Larut Hills in Perak. I was much attracted by their beauty at the time, and have felt a strong interest, I think I may say an enthusiasm, for the family ever since.

Fraser (1949) has recently published a review of the Chlorocyphidae in which he gives diagnoses of several proposed new genera, and an authoritative revision of the African members of the family. His diagnoses, and key to the genera of the family, are based almost entirely on characters of the wing venation.

On the other hand, I have here approached the classification of the group largely from a consideration of the geographical distribution of its members. This must serve as an apology for this Survey and as an explanation of any such divergences as it may contain between Fraser's account and my own.

It is hardly necessary for me to add that I fully share his appreciation of the importance of venational characters which he has done so much to interpret.

I have to thank him for much generous help in making this Survey, and further for invaluable assistance in the way of material, literature and correspondence for upwards of thirty years. I have also to acknowledge my indebtedness to Mr. D. E. Kimmins, of the British Museum (Nat. Hist.), not only for the figures illustrating this paper, but for information always most obligingly given, and for the suggestion that I should add an account of the new geographical race of *Melanocypha* described below. I must, also, thank the authorities of the British Museum for giving me permission to deal with the specimens.

Equally am I under an obligation to Mr. M. A. Lieftinck of the Museum of Buitenzorg, especially for a photograph of a male example of the Sumatran race of *Melanocypha snellemanni*, for specimens of both sexes of the insect, and for very many other kindnesses.

I must record my thanks also to Mr. Cowley, who has given me notes and references on material not easily available to me; to Mrs. L. K. Gloyd, of the University of Michigan, for information about the Forster Collection now in Michigan; and to Dr. Chapin, of the U.S. National Museum, for information and wing photos. Lastly I have to thank Professor Zeuner for his kindness in replying to queries on geological matters.

In the following account I use the term Wallacea purely as a convenience. By it I mean the Austro-Oriental Subregion as defined by Kloss (1929, *Bull.*

Raffles Mus. **2** : 5), bounded to the West by Wallace's Line, and to the East by Weber's Line. N. Wallacea is, of course, Celebes with satellite islands; S. Wallacea includes the chain of islands from Lombok to Timor.

DEFINITION OF THE FAMILY CHLOROCYPHIDAE.

A family of the Zygoptera, with accessory antenodal and postnodal cross-nerves of the costal and postcostal series, which do not coincide. Always five or more antenodals in all. No basal antenodals. Quadrilateral long and narrow, always traversed. Arculus at or about the level of the second primary antenodal. In the simpler forms (Series *Libellago*) sectors of arculus rise from the same point; in other Series distinctly separated at their origin. Also in the series Libellago veins R2 + R3 straight or nearly so, and R4 + R5 and IR3 descend from it. In other genera R2 + R3 and R4 + R5 forked, and IR3 rises more or less symmetrically in the fork.

Eyes close set on the head when compared with other Zygoptera; clypeus projecting in a snout-like way, which is diagnostic for the family.

Abdomen fairly stout, often rather depressed, and shorter than the hind wing (except in males of *Rhinoneura*).

Body-colour black, ornamented with a pattern of yellow, red or blue in the males; females generally dull black, with yellow pattern. Hinder two pairs of tibiae of male often pruinose or chalky white on their anterior surfaces.

Larva with stout body, ratio of length to breadth about 4 : 1. Legs long and slender; antennae 8-jointed, second joint from base being long, about one-third length of whole antenna. Mask cleft. Lateral gills (cerci) bayonet-like, median gill (appendix dorsalis) short, conical.

The *larva* lives in streams where the flow of water is rapid and often shallow. It crawls on the roots of water plants, or among the trash that accumulates on the bed of such streams.

No family of the Odonata is less likely to undergo "accidental" migration. Both adults and larvae are tied down to a very special type of habitat (Fraser, 1949 : 3). The waters of the streams inhabited by the larvae are very well aerated, perhaps a necessary condition for the development of the rich pigmenttation of the males.

The family is distributed all over the Oriental Region, and ranges east into Papua, reaching as far as the Solomon Islands. To the west it has reached tropical Africa.

RELATIONSHIP.

The family has no near ally and is therefore compact in the sense that the genera comprising it are readily recognized.

Fraser (1939) is of the opinion that it originated from some form in the line of the AMPHIPTERYGIDAE, though, of course, all existing forms of that family are specialized in other directions. A clue is given by the larva, which shows some of the special characters found also in the AGRIIDAE, namely, the cleft mask, the long second joint of the antennae, and to some extent the anal appendages. The Indian *Caliphaea* has a larva which in these respects is intermediate between the two families (Fraser, 1943, *Proc. R. ent. Soc. Lond.* (B) **12** : 86, f. 4).

I suggest, therefore, that the CHLOROCYPHIDAE are derived from the same stock as that which has also given rise to the AGRIIDAE, the latter being much more specialized venationally.

HISTORY.

The family took shape in Tertiary times in the great plateau of S.E. Asia, the Sunda Shelf, now represented by the lands of Malaysia and Wallacea. It is probable that the land surface of the Shelf in the Tertiary period was more extensive for long ages of time, and that the distinction between the faunas of different parts of the area was less marked than is the case in the present-day lands of Malaysia and Wallacea.

The original stock were rather small insects, probably not very unlike the existing *Libellago*. At an early stage this stock branched into two main lines of descent. One of these, which I call the series *Libellago* and which contains about 18 per cent. of the living species of the family, has retained a primitive type of venation, and still remains for the most part centred in its original home-land. Broadly speaking, the series has been unprogressive; specific differences seem to be mostly of colour-pattern, and the majority of the species are really very much alike.

One species of *Libellago*, however, has colonized widely, having reached N. India, Indochina, and Hainan; it has, moreover, established itself in S. India, where it has developed a geographical race which occurs also in Ceylon[1], a second race is known from the Nicobar Is. Moreover, in Ceylon there has been a small " radiation " of some three other species, all I think closely related; lastly the Andaman Is. have a single endemic species.

It is worth noting that neither in Ceylon nor in the Andaman or Nicobar Islands does *Libellago* come into competition with any member of the *Rhinocypha* series. It is also curious that the adventurous *lineata* has not been recorded from Borneo. It is common in Java, Sumatra and Malaya, and on the mainland of Asia.

Recently Fraser (1949) has proposed two monotypic genera for species which differ in details of venation from the bulk of the members of the series. One of his genera, *Sclerocypha*, is confined to Celebes; the other, *Melanocypha*, has races in Sumatra and Java. The latter is interesting, as it seems to have made some attempt to emulate the brilliance of many of the series *Rhinocypha* in wing colour.

The other line of descent gives evidence of more progressive evolution than does the *Libellago* series, and contains about 82 per cent. of all species.

Two small side branches, which I have classed as separate " series " may be discussed briefly. These are, firstly, the aberrant Celebesian genus *Disparocypha*, in venation the most specialized genus of the family, having lost entirely the anal vein (cf. the PROTONEURINAE amongst the COENAGRIIDAE). The only known species is recorded from S. Celebes, and one specimen only has been taken. The second is the Bornean genus *Rhinoneura*, a mountain-loving insect in which the male, alone in the whole family, has the abdomen of greater length than the hind wing, possibly the survival of an ancestral character. Both of these " series " seem to be moving along a blind alley and approaching extinction. Both are more closely related to the *Rhinocypha* series than to *Libellago*.

Finally there is the *Rhinocypha* series, the really flourishing and progressive branch of the family.

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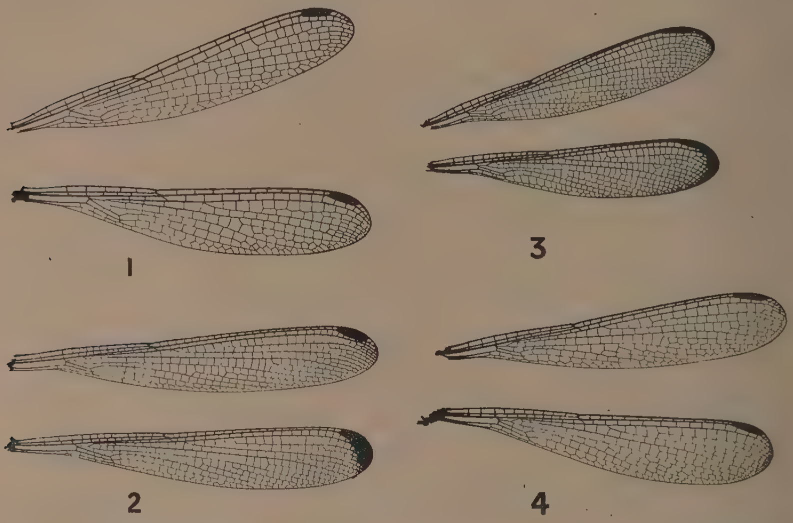
[1] I have later come to believe that *Libellago indica* is a member of the Ceylon radiation, which has managed to establish itself on the Indian mainland.

I have found it helpful to arrange its members in three "grades," which I believe indicate not only levels of development, but also stages at which large scale migration took place.

In the *first grade* I put those genera whose species have not developed the brilliant wing colouring which is so marked in the other grades.

"Specialization" in this family is mainly concerned with sexual characters of the male, and accordingly in this first grade the species may be regarded as the little-modified descendants of early stock of the family. The distribution of these species lends some support to this view. Some few are found in Malaya (mostly in Borneo), one or two in S. Wallacea (and it is likely that *Disparocypha* from N. Wallacea is an experimenting offset also); and colonizing emigrants at about the same level of "specialization" have reached Tropical Africa to become the ancestors of the Ethiopian genera *Chlorocypha* and *Platycypha*. It is noteworthy that no member of the family has been recorded with certainty from Madagascar. The climate and physiography of the island seem very favourable, and it is justifiable to assume that the ancestral forms of *Chlorocypha* must have reached Africa after Madagascar had separated off from the mainland.



Figs. 1–4.—(1) *Libellago lineata* ♀. (2) *Rhinoneura caerulea* ♂. (3) *Rhinocypha spinifer* ♂. (4) *Chlorocypha dispar* ♂. (From specimens in the British Museum.)

I am indebted to Prof. Zeuner for information that "the separation is believed to have been effected by Miocene times, although the intervening channel was, according to Krenkel, reduced in width in the course of the Pleistocene. As the CHLOROCYPHIDAE require rapidly running streams they are necessarily restricted to mountain regions at the present day. But wherever perennially flowing streams were available during humid phases, it is conceivable that these insects could occur at lower elevations."

Chlorocypha, then, must have reached Africa at some time later than the Miocene Period, by a land route which is obviously not suited to them at the present. Zeuner (1942, *Trans. zool Soc. Lond.* **25** : 152 *et seq.*) discusses the effects of a possible shifting to the north of the meteorological equator, and other differences in the past which may conceivably have made the coast line of the western part of the Indian Ocean less arid than it now is. *Indocypha* and *Cyrano* may be back eddies from this first migration.

The second and third grades emerged later, at a level at which the ornamentation of the male had become the dominant feature of specialization in the family.

The *second* grade is still actively developing, and holds the largest number of species. It has colonized to the East, and has established itself in the Philippine Islands, in Papua as far as the Solomon Islands, and in intermediate islands. In Borneo a small group (*cucullata*) has developed a special character of its own, and two other Bornean species are perhaps re-entrants from the East by way of Palawan (*humeralis* and *eximia*). It is well represented in N. Wallacea, but not in the islands of S. Wallacea.

Three aberrant and isolated species are here referred with some doubt. The first, *turconii* from the Philippines, has a superficial resemblance to the Javanese species *anisoptera*. The second is *drusilla* from E. China, concerning which Ris has noted (MSS.) that it is like a " very odd *tincta*." Lastly the enigmatic *ogasawarensis* is from the Bonin Is.

The species of this grade from W. Malaysia and Indochina fall into species groups which are very distinct from those of Borneo and further East, so much so as to suggest that at the time when these groups were differentiating there must have been some geographical barrier in existence between Borneo and the rest of what is now Malaysia, whilst the latter was more closely connected with the Asiatic mainland. W. Malaysia has two small groups, related to each other, namely, *heterostigma* and *anisoptera*. No member of these groups has so far been found in Borneo, whilst to the north the grade is represented by the monotypical genus *Paracypha* and the group *trimaculata*. These resemble the Malaysian species in having the abdomen of the male almost entirely black, and they have retained a relatively primitive type of penis.

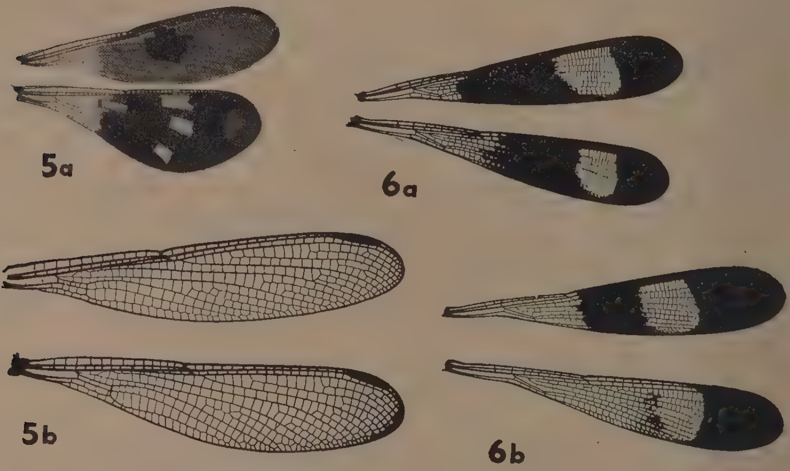
Conditions in the mountainous areas of S.E. Asia seem to have favoured the development of brilliant wing-colouring and rather large size in the Oriental members of the family, as well as the development of " fenestrae." These reach their fullest development in species of both the second and third "grades." Possibly this is an example of the occurrence of " parapotency, i.e. of the phylogenetic antiquity of certain alleles (Mayr)."

The *third* grade (*Aristocypha*) is distinguished from the two others by the development of the " mesothoracic triangle " which is present in both sexes, but serves as an ornament or recognition mark especially in the male.

The species are found only to the west of Wallace's Line, and are poorly represented in Borneo, thus to some extent supporting the suggestion of the former existence of some geographical barrier between that island and the more westerly lands of Malaysia. Borneo has, in fact, only two representatives of the grade. One of these, *H. biseriata*, is in all probability a recent arrival, the other, *S. petiolata*, is shared with Sumatra and Malaya.

West Malaysia is the headquarters of the genus *Heliocypha*. One of its species has made its way to the north and west as far as Peninsular India (*bisignata*); another has travelled as far east as S. China and Formosa (*perforata*).

Aristocypha, the most advanced genus, is massed along the S. slopes of the great mountain ranges of India, Burma and W. China. Its group *iridea* is annectant with *Heliocypha*, and in some respects primitive. The group *quadrimaculata* extends far to the East, one of its species has travelled as far south as Malaya.[2]



Figs. 5–6.—(5) *Aristocypha fulgipennis*. (*a*) male ; (*b*) females. (From specimens in the British Museum.) (6) Wings of males of *Melanocypha snellemanni*. (*a*) *snellemanni* ; (*b*) *javana*. Figs 5*a*, 5*b* not on the same scale

More westerly in distribution the *trifasciata* group is found as far to the west as Kumaon, but has a limited range to the east. It is interesting as showing a progressive reduction in wing colour from *trifasciata* and *bifasciata* to *immaculata*, which has entirely hyaline wings, the only member of either grades 2 and 3 to be so distinguished. Lastly, the magnificent *fulgipennis* is found in Siam and French Indochina.

The single species of *Heterocypha* from Burma is rather intermediate between *Heliocypha* and *Aristocypha*, whilst *Calocypha* segregated in S. India seems to have *Sundacypha* as its nearest ally.

Classification.

The classification remains essentially as it was left by de Selys, when allowance is made for changes in terminology and nomenclature.

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[2] Fraser has recorded *A. fenestrella* from " Sintang " in Borneo (1934). It has not been found elsewhere in Borneo, and the record is, I think, due to an error. Fraser (*in litt.*) agrees that this may be so.

His " Legion Libellago " of the CALOPTERYGIDAE (now called AGRIIDAE) is the same as the family CHLOROCYPHIDAE of to-day, and his three genera, *Libellago, Micromerus* and *Rhinocypha,* still represent the main grouping of the family.

Ris (1916, *Ent. Mitt.* **5** : 303 *et seq.*) left it, with his remarkable new genus *Disparocypha,* in the CALOPTERYGIDAE. Tillyard (1917, *Biology of Dragonflies*) treated it as a section of the EPALLAGINAE in the same family, whilst Munz (1919, *Mem. Amer. ent. Soc.* **3**) made a new subfamily for *Disparocypha,* leaving the three other genera then known with the EPALLAGINAE.

It was suggested by myself that the group should rank as a subfamily, the LIBELLAGINAE (1920, *Rec. Ind. Mus.* **19** : 185), and from then on until 1937 it was known either as the LIBELLAGINAE or was given full rank as a family (Lieftinck, 1934, *Treubia,* **14** : 385), LIBELLAGINIDAE.[3]

In 1916 Ris had already pointed out that there was ambiguity in the use of the generic name *Micromerus,* and in 1934 Fraser (*Fauna of British India, Dragonflies* **2** : 59) proposed, in strict accordance with the laws of priority, to use the name *Libellago* for the species so long grouped under the generic name *Micromerus.* He suggested the name *Chlorocypha* for the African species which had previously been put by de Selys and other Odonatologists in *Libellago.* He gave *Agrion lineata* and *Agrion dispar* as the respective type species.

The full argument for these changes has been stated for me by Mr. Cowley, as follows :

" In 1840 Selys fixed the type of *Libellago* as *lineata* Burmeister. Therefore Rambur's genus *Micromerus* (Rambur, 1842, genotype *lineatus* Burmeister) was a synonym."

" But Selys (1840) wrote of *Libellago* : " Example *Agrion lineata.* La *fenestrata* et la *fulgipennis* en font aussi partie . . ."

" Therefore, rigidly construed he did not fix the genotype, which must be selected from one of the three species mentioned.

" Rambur (1842) put *fenestrata* (under the names *vitrella* and *infumata*) and *fulgipennis* in his genus *Rhinocypha,* and *lineata* in his genus *Micromerus.*

" Selys (1853) left *fenestrata* and *fulgipennis* (under the name *fulgidipennis*) in *Rhinocypha,* made *lineata* the type of *Micromerus,* and *dispar* Beauv. the type of *Libellago.*

" Kirby (1890) fixed *tincta* Rambur as the type of *Rhinocypha.*

" Fraser (1928) proposed the new name *Chlorocypha* for *Libellago* Selys (1853), genotype *dispar* Beauv., and reinstated *Libellago* Selys, 1840, instead of *Micromerus* Rambur, 1842, with *lineata* Burmeister as genotype. In this he was followed by Lieftinck (1932).

" The genotype of *Libellago* seems to have been actually fixed by Fraser in 1934.

" Cowley (1937) corrected the designation of the family to CHLOROCYPHIDAE.

" The synonymy therefore is as follows :

$$\left.\begin{array}{l}\textit{Libellago}\text{ Selys (1840)}\\ = \textit{Micromerus}\text{ Ramb. (1842) }\textit{et auct.}\end{array}\right\}\text{ and }\left\{\begin{array}{l}\textit{Chlorocypha}\text{ Fraser (1928)}\\ = \textit{Libellago}\text{ Selys (1853).}\end{array}\right.$$

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[3] *Libellago* is an artificial word, and it is apparently a matter of taste whether or not it should be given a Latin form in compounds.

'Selys, 1840, *Mon. Lib. Eur.* : 200.
Rambur, 1842, *Ins. Neur.* : 238.
Selys, 1853, *Bull. Acad. Belg.* **20** Annexe : 57–64.
Kirby, 1890, *Cat. Odonata.*
Fraser, 1928, *J. Bombay nat. Hist. Soc.* **32** : 684.
Lieftinck, 1932, *Konowia* **11** : 1.
Fraser, 1934, *Fauna Brit. India, Odonata* **2** : 59."

Thus, unfortunately, the familiar generic name *Micromerus* is dropped altogether, its species being transferred to *Libellago*; and species which for about one hundred years have been put into *Libellago* must be transferred to *Chlorocypha*.

A number of new genera have been described in the family during the last thirty years, most of them monotypical. In this paper I have subdivided the largest of the old genera, *Rhinocypha*. Nowadays such a move needs explanation or even apology (Mayr, *Systematics and the origin of Species*).

I fully agree with a recent remark of Lieftinck (1949, *Nova Guinea* **5** : 83): "If the genus is to retain its importance, the modern broadening of the species concept must be accompanied by a compensatory adjustment in the genus concept, and generic names should remain a means of denoting groups of related species, rather than become redundant equivalents of specific names."

My own view is that the genus should be a useful and convenient index or "pigeon-hole" for the systematist, and I have here, I believe, so dealt with it.

To extend the genus to its full capacity and strictly logically would give rise to inconvenience. Thus I think many Odonatologists are prepared to admit that the African *Chlorocypha* are difficult to separate from the *spinifer* group of *Rhinocypha*; but on geographical grounds, if for no other reason, it is surely convenient to keep them separately labelled.

I venture to put in a plea for the use of sexual characters in defining genera in this family at least. For example, the small genus *Rhinoneura*, which I have put in a series of its own, and which no one has refused to accept as very distinct from *Rhinocypha*, is separated essentially by sex characters of the male from the latter genus. I make the reservation that whilst I have not been able myself to find other characters of importance, it is admittedly possible that such characters exist.

But for the present I think that to sink *Rhinoneura* in *Rhinocypha* would not help in any way to clarify the relationship of the members of the family, and would even be inconvenient to systematic workers.

If the distribution of the species of the family is plotted on a map many of them are found to lie in definite geographic groups. Some of these are clearly "species groups" as defined by Zeuner, equivalent to Huxley's "geographical genera." But there are also species distributed here and there over the area covered by the family, which do not fit into any group. These are the monotypical species. In contrasting "group" with "monotype" I do not wish to suggest any cast-iron categories, but rather I picture the descent of all existing members of the family from a single ancestral group in the remote past. The heirs of this old population have undergone different experiences in geological time, and as a result the development of the numerous breeds of the present day has arisen—in some cases the group : in others it has happened that a species has for long ages continued to exist as a single line of descent, whilst no doubt undergoing evolutionary changes. Or again it is likely that some monotype may be the last survivor of a group otherwise extinct.

The geography and geological history of the great Archipelago of S.E. Asia make it a natural laboratory on the grand scale for experiments in speciation ; and the experiments are still in progress. We can see only a cross-section in time of a growing branching organization, whose roots and whose ultimate flowering are alike hidden from us.

The alternative to giving generic names to geographical genera is to label groups under the name of a typical species, and, of course, for geographical species the name of the first-described form of the species. I have largely used this method in this " survey." In my experience the use of trinomials suggests, quite wrongly, a sort of standard type-race from which other breed of the species have been derived. It is, of course, inaccurate to write (say) of *R. semitincta* that it is a race or subspecies of *R. tincta*. Both of them are races derived from an unknown ancestor.

In his paper already referred to, Zeuner illustrates the phylogeny of the *Troides* by figures showing the probable branching off of species and subspecies from ancestral forms at different levels of geological time.

For these levels or " strata " he uses an alphabetical notation ; thus the ultimate stratum, that of the present period (Holocene), is denoted by Z, that immediately before it (Pleistocene) as Y, still earlier time by X, and so on.

Might it not be possible to distinguish the status of a species where necessary by using this notation ?

Thus *R.* (*Z*) *tincta* and *R.* (*Z*) *semitincta* could indicate the existing races of *R.* (*Y*) *tincta*, the (presumably) Pleistocene ancestral form.

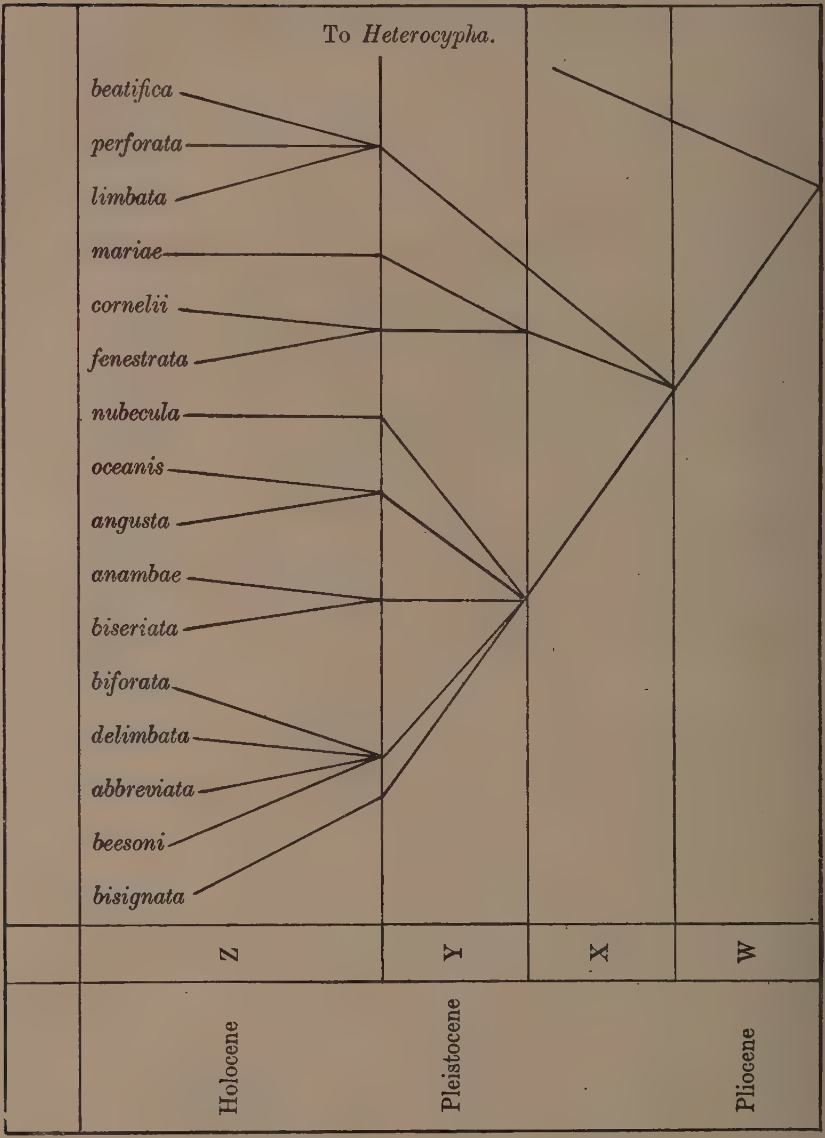
The diagram overleaf, based on similar diagrams given by Zeuner, will serve to show how the suggestion can be applied in the case of a particular genus, in this case *Heliocypha*. It indicates how the existing forms may have diverged since Pleistocene times, though it must be understood that I do not intend it as a definite " family tree."

Cowley (1937, *Trans. R. ent. Soc. Lond.* **86** : 1–18) has published an account of the penis in the family. His work was undertaken to determine to what extent this structure affords group-characters.

For this purpose he examined, and in his paper figured, the penis of some 70 species and subspecies. He found that he could assign these to ten distinct groups, the chief group characters being provided by the internal and external branches of the lateral, apical process. He assumed that the forms with an undifferentiated external branch are the more primitive, those with elaborate branches the more specialized and recent.

His groups are arranged in order of increasing complexity, the first the most primitive, the last the most specialized.

He remarks that in groups 2, 4 and 8 the specific differences are slight and difficult to assess, whilst in his groups 3, 6 and 7 specific differences are well marked. Furthermore, he thought it possible to trace a line of development from group 2 through 3, 4 and 7 ; with 5 and 6 branching as more specialized offshoots from near the apex of this line ; whilst a second line led direct from 2 to 8, with a further development from 8 to 9. Lastly group 10 stands apart as the most complex.


To *Heterocypha.*
beatifica
perforata
limbata
mariae
cornelii
fenestrata
nubecula
oceanis
angusta
anambae
biseriata
biforata
delimbata
abbreviata
beesoni
bisignata
Z
Y
X
W
Holocene
Pleistocene
Pliocene

Apart from Cowley's study, the only notice of the structure of the penis in the family is a short account by Schmidt (1915, *Zool. Jahrb.* (*Anat.*) **39** : 87–200) of those of a species of *Chlorocypha* (*Libellago*), of *R. tincta* and of *R. quadrimaculata* ; and by Kennedy (1920, *Ohio J. Sci.* **21** : 19–29) of *L. stigmatizans* and *R. eximia*.

The evidence is, of course, incomplete, not half of the existing species having been examined ; but, allowing for this, and for difficulty in studying and interpreting a structure so small and complicated, I find Cowley's Groups agree to a significant extent with an arrangement of the genera and species on geographical lines. I must admit that there are differences which I cannot at present account for, but it is unlikely that an increase in the complexity of the penis necessarily keeps step with increase of specialization in other parts of the organization.

To show this I have tabulated shortly his findings with the classification suggested in this survey. I have substituted the term "Type" for Cowley's "Group," and have in the case of the series *Rhinocypha* indicated to which of the three Grades here proposed any given species or species-group belongs by Roman numerals after the name.

Type 1.

Indocypha vittata Selys.	I.

Type 2.—Series *Libellago*. (All species so far examined, about 15.)

Rhinocypha pagenstecheri Forster	I.
,, group *ustulata*	II.
,, group *ignipennis* . . .	II.
Paracypha unimaculata Selys . . .	II.
Aristocypha iridea Selys	III.

Type 3.

Sundacypha petiolata Selys . . .	III.
Calocypha laidlawi Fraser	III.

Type 4.

Rhinocypha group *tincta*	II.
,, *spinifer* Laidlaw . . .	I.
,, *moultoni* Laidlaw . . .	I.
Heliocypha perforata Selys	III.

Type 5.

Rhinocypha cognata Kimmins . . .	I.

Type 6.

Rhinoneura "series."

Type 7.

Rhinocypha group *cucullata*	II.
,, ,, *heterostigma* . . .	II.
,, ,, *anisoptera* . . .	II.

Type 8.

Heliocypha fenestrata Ramb.	III.
,, *biforata* Selys	III.
,, *biseriata* Selys	III.
,, *angusta* Selys	III.
,, *mariae* Lieftinck	III.
Aristocypha group *quadrimaculata*	III.
,, ,, *trifasciata*	III.
,, ,, *fulgipennis*	III.

Type 9.

Cyrano unicolor	I.

Type 10.

Chlorocypha (8 species examined, including *Platycypha*)	I.

Mr. Cowley has told me (*in litt.*) that the penis of *ogasawarensis* is similar to that of *pagenstecheri*. It falls, therefore, under Type 2.

Lieftinck (1949) has figured the same structure for his new species *R. liberata* and finds it agrees well with that of *ustulata*.

List of species included in the family.

With Diagnoses of New Genera, and of Suggested "Series" and "Grades."

I believe that the following list is complete with the exception of *Rhinocypha pallidifrons* (Ris, 1927), described from an unique female specimen. As it seems to me impossible to give any satisfactory suggestion of its relationship to other species of the genus it has been omitted.

A. Anal Vein Present, Normal.

I. Series *Libellago*.

Sectors of arculus rising from the same point. Arculus sharply angled. Antenodals few, usually not exceeding 9 in number. R2 + 3 not arched forward. Wings usually narrow. Penis of all species examined of Type 2.

(*a*) Anal vein rising proximal to basal antenodal. Not more than 7 antenodals.

Libellago Selys, 1840. (*Micromerus* Selys *et auctt.*)
Genotype *Calopteryx lineata* Burmeister, 1839.

Group *stigmatizans*.

Pterostigma present on all four wings of male.

stigmatizans Selys, 1859. Malaya, Sumatra.
hyalina Selys, 1859. Malaya. Sumatra, Borneo.
mima Lieftinck, 1932. Borneo.
naias Lieftinck, 1932. Flores, Sumba.
phaethon Laidlaw, 1930. Borneo.
sticticus Selys, 1869. Borneo.

Group *lineata*.

No pterostigma on male fore wing.
Species from Malaysia, Ceylon and Mainland of Asia.

lineata lineata Burmeister, 1839. Java, Sumatra, Malaya, to N. India, China, Formosa.
,, *indica* Fraser, 1933. S. India, Ceylon.
,, *blanda* Selys, 1853. Nicobar Is.
adami Fraser, 1939. Ceylon.
andamanensis Fraser, 1924. Andaman Is.
aurantiaca, Selys, 1879. Malaya, Sumatra, Borneo.
dorsocyana Lieftinck, 1937. Borneo.
finalis Selys, 1869. Ceylon.
greeni Laidlaw, 1924. Ceylon.
semiopaca semiopaca Selys, 1873. Malaya, Borneo.
,, *martinae* Karsch, 1891. Sumatra.
sumatrana Selys, 1879, Sumatra, Java.

Species from Celebes :

asclepiades Ris, 1916. S. Celebes.
ufescens Selys, 1873. Celebes.
xanthocyana Selys, 1869. N. Celebes.

(*b*) Anal vein separating from wing margin distal to level of basal antenodal. Usually 9 antenodals. Only one row of cells between the anal vein and hind margin of wing. Costal vein thickened in the male.

Sclerocypha Fraser, 1949.
Genotype and only species *Micromerus bisignatus* MacLachlan. Celebes.

(*c*) Anal vein rising well distal to basal antenodal nerve. Usually 9 antenodals. Two rows of cells may be present between the anal vein and hind margin of wing.

Melanocypha Fraser, 1949.
Genotype and only species *Micromerus snellemanni* Selys.

snellemanni snellemanni Selys, 1853. Sumatra.
snellemanni javana subsp. n. Java.

All African species formerly referred to *Libellago* are now transferred to *Chlorocypha* or *Platycypha*.

Vittata and *unicolor* from Asia are now respectively the types of *Indocypha* and *Cyrano*.

In addition the synonymy of names proposed for species of *Micromerus* is as below :

affinis Laidlaw, 1902.	*Libellago semiopaca* Selys.
annandalei Laidlaw, 1903.	,, *aurantiaca* Selys.
bisignatus MacLachlan, 1870.	*Sclerocypha bisignata* MacL.
obscurus Kirby, 1884.	*Libellago lineata* Burm.
robropictus Martin, 1902.	*Sundacypha petiolata* Selys.
signatus Krüger, 1898.	*Libellago lineata* Burm.
snellamanni Selys, 1879.	*Melanocypha snellemanni* Selys.
uxor Rambur, 1854.	*Libellago lineata* Burm.

Schmidt (1935) has suggested that *sumatrana* is a local race of *aurantiaca*. Both forms occur in Sumatra, and I prefer to keep them distinct.

II. Series *Rhinoneura*.

Sectors of arculus distinct at origin. R2 + 3 and R4 + 5 symmetrically forked. Wings narrow (ratio length to breadth 5·5 : 1 or greater). Pterostigma inflated. Wings hyaline, limbate in the male. Abdomen of male surpassing the hind wing considerably in length. Penis type 6.

Rhinoneura Laidlaw, 1915.
Genotype *Rhinoneura villosipes* Laidlaw, 1915.

caerulea Kimmins, 1936. Borneo, Mt. Dulit, 3700 ft.
villosipes Laidlaw, 1915. Borneo, Mt. Kinabalu.

R. villosipes has relatively the narrowest wing of any member of the family, the length to breadth ratio being about 6·75 : 1.

III. Series *Rhinocypha*.

Sectors of arculus well separated at origin. Arculus obtusely angled. R2 + 3 strongly arched forward. Abdomen of male shorter than hind wing.

Grade I.

Wings of male hyaline or limbate. Mesothoracic triangle not enlarged.
(i) Veins MA and CuP not diverging.

(*a*) Asiatic species. Pterostigma a little dilated. Venation denser than in the next genus, and wings relatively rather wider. Apex of male fore wing sometimes limbate. Penis, where known, of types 2, 4 or 5.

Rhinocypha (pars).
Genotype *Rhinocypha tincta* Rambur.

cognata Kimmins, 1936. Borneo (Mt. Dulit).
moultoni Laidlaw, 1913. Borneo (Kinabalu).
pagenstecheri pagenstecheri Forster, 1897. Flores, Lombok.
pagenstecheri timorana Lieftinck, 1936. Timor.
spinifer Laidlaw, 1930. Borneo.
sumbana Forster, 1897. Sumba.
stygia Forster, 1903. Borneo.
xanthe Ris, 1927. Sumatra.

(*b*) African species. Pterostigma not dilated. Venation rather open. In all species examined the penis is referred to type 10.

Male tibiae not dilated.
Chlorocypha Fraser.
Genotype *Agrion dispar* Palisot de Beauvois.

cancellata Selys, 1879. Cameroons.
curta (Hagen) Selys, 1853. Sierra Leone.
cyanifrons Selys, 1873. Gaboon.
dispar Palisot de Beauvois, 1805. Gaboon.
glauca Selys, 1879. Calabar.
luminosa Karsch, 1893. Togoland.
molindica Fraser, 1948. Congo.
neptunus Sjostedt, 1899. Cameroons.
rubida (Hagen) Selys, 1853. Cameroons.
selysi Karsch, 1899. W. Africa.
straeleni Fraser, 1949. Uganda.
tenuis Longfield, 1936. Ruwenzori.
victoriae Forster, 1914. Uganda.

Two hinder pairs of tibiae dilated in male.
Platycypha Fraser, 1914.
Genotype *Libellago caligata* Selys.

caligata Selys, 1853. E. Africa to Natal.
lacustris Forster, 1914. Uganda.

(ii) Veins MA and CuP diverging.

(*a*) An intercalary vein rising well before level of nodus. Penis type 9.

Cyrano Needham, 1939.
Genotype and only species *Rhinocypha unicolor* Hagen (in Selys), 1869. (= *Libellago asiatica* Selys, 1879). Philippine Is.

(*b*) Intercalary vein starting after level of nodus. Penis type 1.

Indocypha Fraser, 1949.
Genotype *Libellago vittata* Selys, 1879.

vittata Selys, 1879. Burma.

svenhedini Sjostedt, 1932. Annam.

Fraser (1949) has given a full revision of *Chlorocypha* and *Platycypha*. To make my list of species as complete as possible I have copied the list of species which he has given as well defined ; and have left out a few names which he regards of doubtful value.

Rhinocypha sumbana was originally described as a " sub-race " of *pagenstecheri*. Lieftinck regards it as a distinct species, and *braueri* Kruger, 1898, as a synonym of *sumbana*.

I. sven-hedini is perhaps a local race of *vittata*.

The position of *pagenstecheri* in this " Grade " is a little doubtful ; it may lie better in " Grade " II.

None of the hyaline winged *Rhinocypha* were known to de Selys.

Grade II.

Mesothoracic triangle not enlarged. Wings in male with well-defined, opaque, brownish black area ; in female usually deeply tinged with dark brown, and with a milky-white patch at apex of hind wing.

(*a*) A single row of cells between the anal vein and the wing margin.

Rhinocypha (pars restr.).

Group *tincta*. (Penis, type 4.)

albistigma Selys, 1875. Batchian.
colorata Selys, 1869. Philippine Is.
eximia Selys, 1873. Palawan, N. Borneo.
frontalis Selys, 1873. Celebes.
humeralis Selys, 1873. N. Borneo.
hageni Kruger, 1898. Sulu Archipelago.
monochroa Selys, 1873. Celebes.
phantasma Lieftinck, 1935. Bouton.
tincta tincta, Rambur, 1842. Waigeou.
tincta adusta Lieftinck, 1949.
,, *amanda* Lieftinck, 1938. N.E. New Guinea.
,, *dentiplaga* Lieftinck, 1938. N.E. New Guinea.
,, *retrograda* Lieftinck, 1938.
,, *sagitta* Lieftinck, 1938. W. New Guinea.
,, *semitincta* Selys, 1869. Moluccas, Aru, Kei Is., S. and E. New Guinea, ? Cape York.

Group *drusilla*.

drusilla, Needham, 1930. E. China, Fukien and Chekiang.

Group *ustulata*. (Penis, type 2.)

aurulenta Forster, 1903. Buru.
liberata Lieftinck, 1949. S.E. Solomon Is.
ustulata Brauer, 1867. Ceram, Amboin, Soela Is.

Group *ogasawarensis*.

ogasawarensis Oguma, 1913. Bonin Is.

Group *turconii*.

turconii Selys, 1891. Philippine Is., Zebu.

Group *cucullata.* (Penis, type 7.)

aurofulgens Laidlaw, 1931. N. Borneo.
cucullata Selys, 1873. N. Borneo.

Group *heterostigma.* (Penis, type 7.)

heterostigma heterostigma Rambur, 1842. Java.
,, *io* Fraser, 1926. S. Sumatra.
pelops Laidlaw, 1936. Malaya, Tenasserim.
selysi Krüger, 1898. Sumatra, Java.

Group *anisoptera.* (Penis, type 7.)

anisoptera Selys, 1853. Sumatra, Java.

Group *trimaculata.* (Penis, type 2.)

ignipennis Selys, 1879. Assam, Upper Burma.
trimaculata Selys, 1853. Assam, Tibet.

(*b*) Two rows of cells between the anal vein and the hind margin of the wing.

Paracypha Fraser, 1949. (Penis, type 2.)

Genotype and only species *Rhinocypha unimaculata* Selys, 1853. Sikkim, Assam.

Grade III.

Mesothoracic triangle enlarged in both sexes. Wings of males as a rule brilliantly coloured and with fenestrae ; hind wing in many species much widened. Penis (with few exceptions) of type 8. Found only to west of Wallace's line.

(*a*) Anal vein rises at or distal to the level of the second primary antenodal.

Fenestrae absent. Penis, type 3.

Calocypha Fraser, 1927. (restr.)

Apices of both pairs of wings rounded, venation rather open. Mesothoracic triangle narrow, extending the whole length of the mid-dorsal carina. In the male the apices of both pairs of wings are opaque, blackish brown.

Genotype and only species *Rhinocypha laidlawi* Fraser, 1924. S. India.

Sundacypha gen. n.

Apices of hind wings rounded more definitely than those of fore wings; in the males only the hind wings have their apices opaque. Mesothoracic triangle only about one-quarter the length of the mid-dorsal carina. Venation rather dense.

Genotype and only species *Rhinocypha petiolata* Selys, 1859. Malaya, Sumatra, Borneo.

(*b*) Anal vein rises well proximal to level of the second primary antenodal.

Heliocypha Fraser, 1949.

Wings rather narrow. Ratio length to breadth from 5 : 1 to 4·5 : 1. Reticulation rather dense. Mesothoracic triangle from about one quarter to one-third the length of the mid-dorsal carina. Fenestrae usually present.

Genotype *Rhinocypha bisignata* Selys, 1853.

Group *biforata*. (Penis, type 8.)

angusta angusta Selys, 1853. Sumatra.
,, *oceanis* Lieftinck, 1945 (1947). Engano Is.
biforata biforata Selys, 1859. Malaya, Tonkin, Hainan.
,, *abbreviata* Fraser, 1928, Assam.
,, *beesoni* Fraser, 1923 N. India.
biforata delimbata Selys, 1879. Burma.
biseriata biseriata Selys, 1859. Borneo.
,, *anambae* Laidlaw, 1932. Anamba Is.
bisignata Selys, 1853. S. India.
nubecula Lieftinck, 1948. N. Sumatra.

Group *perforata*. (Penis, types 4 and 8.)

fenestrata fenestrata Burm., 1839. Java.
,, *cornellii* Lieftinck, 1945 (1947). Bali.
mariae Lieftinck, 1930. S. Sumatra.
perforata perforata Percheron, 1835. Indochina, Formosa, China.
,, *limbata* Selys, 1879. Assam, Burma, Malaya.

Heterocypha gen. n.

Wings rather broad, ratio, length to breadth a little less than 4 : 1. Apices well rounded. Venation rather open. Anal vein tending to be zigzagged under the quadrilateral. Mesothoracic triangle about one-half the length of the mid-dorsal carina.

Genotype and only species *Rhinocypha vitrinella* Fraser, 1935. Assam.

Aristocypha gen. n.

Wings of males broad, ratio, length to breadth from about 4 : 1 to almost 3 : 1. Reticulation dense. Cells often much elongated transversely in the distal part of the wing. Mesothoracic triangle extending the whole length of the mid-dorsal carina.

Genotype *Rhinocypha quadrimaculata* Selys, 1853.

Group *iridea*. (Penis, type 2. Ratio, length to breadth of hind wing about 3·5 : 1.)

iridea Selys, 1891. Upper Burma.
kerri Fraser, 1933. S. Shan States.

Group *quadrimaculata*. (Penis, type 8. Ratio, length to breath of hind wing about 3·5 : 1.)

cuneata Selys, 1853. N. Bengal, Assam.
fenestrella Rambur, 1842. Burma, China, Indochina, Malaya.
quadrimaculata Selys, 1853. Kashmir, Nepal, Kumaon.
spuria Selys, 1879. N. Burma, Assam.

Group *trifasciata*. (Penis, type 8. Ratio length to breadth of the hind wing about 3·75 : 1.)

hilaryae Fraser, 1927. Upper Burma.
immaculata Selys, 1879, Assam (Khasi Hills).
trifasciata trifasciata Selys, 1853. N.W. India.
,, *bifasciata* Selys, 1879. Bengal, Assam.

Group *fulgipennis*. (Penis, type 8. Ratio, length to breadth, about 3 : 1.)

fulgipennis Guerin, 1831. Annam, Tonkin.

Fraser has pointed out (*in litt.*) that he thinks *kerri* should stand as a distinct species, though closely allied to *iridea*.

The two are well separated from the other species of *Aristocypha*, and the colour pattern of the male wing can be derived from a generalized pattern of the *Heliocypha* type.

Cowley (*in litt.*) suggests that the species from China referred by Needham to *cuneata* is really *fenestrella*, and that *cuneata* has a much more restricted distribution.

B. ANAL VEIN ABSENT.

IV. Series *Disparocypha*.

Wings hyaline; MA straight; CuP not reaching the level of the nodus. Outer end of pterostigma wider than inner end.

Disparocypha Ris, 1916.

Genotype and only species *biedermanni* Ris, 1916. S. Celebes.

Known from a single male.

Munz (1919, *Mem. Amer. ent. Soc.* **3** : 13) put the genus in a special sub-family, contrasted with the other sub-families of the AGRIONIDAE recognized by him. But as this seems to me to be a false antithesis, I prefer to treat *Disparocypha* as a special " series " of the CHLOROCYPHIDAE.

APPENDIX I.

Melanocypha snellemanni Selys, **javana** subsp. n.

Described from 2 males from the MacLachlan collection, now in the British Museum.

They are labelled " Preangan Java," followed by a name which is indecipherable, but looks like " Ledru." No date is given. " Preangan " should read Priangan, a district in S.W. Java. The Museum label reads " MacLachlan Coll. B.M. 1938–674."

Length of hind wing 24 mm.; breadth 4 mm. Length of abdomen 17·5 mm. Index of antenodal costal and post-costal cross-nerves, in the eight wings available, as below (a and b); c is the same index in an example of the Sumatran form.

$$\text{a.}\ \begin{array}{cc} \frac{9}{6} & \frac{8}{7} \\ \hline \frac{9}{6} & \frac{9}{7} \end{array} \qquad \text{b.}\ \begin{array}{cc} \frac{8}{6} & \frac{9}{6} \\ \hline \frac{9}{7} & \frac{9}{7} \end{array} \qquad \text{c.}\ \begin{array}{cc} \frac{8}{6} & \frac{10}{7} \\ \hline \frac{9}{8} & \frac{9}{7} \end{array}$$

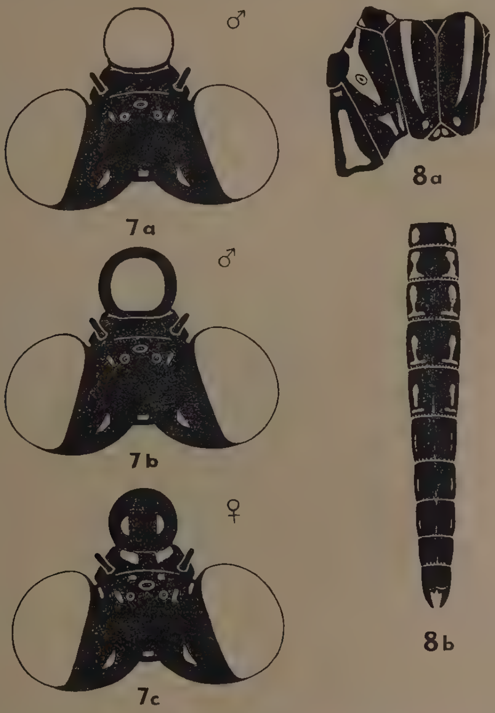
In two of the fore wings of *javana* Ac lies about midway between the levels of the two primary antenodals; in the other wings it lies nearly under the second primary antenodal. No pterostigma on male fore wing.

The forking of the radial sectors is more nearly symmetrical in the wings of the specimens I have been able to examine than in *Libellago*; this is shown in Fraser's figure of the venation. But none of my specimens show more than a single row of cells between the anal vein and the hinder margin of the wing.

Head.—Black, except the nasus, which is entirely orange-yellow, *without* a black margin; and the following markings on the head. A pair of minute spots, one on either side of the posterior ocelli, and a larger pair behind these, rather triangular in shape; a small mark between them on the occipital border. These are all dull yellow.

Prothorax (this is rather crushed in both specimens and difficult to examine).—Black above with a yellow spot on posterior margin at its middle and sides, so far as can be distinguished, yellow, edged with black, and with an irregular vertical, black band running from the black dorsum to the ventral surface.

Thorax.—Black, marked as follows: A rather broad antehumeral band, pointed above extends nearly to the antealar sinus on either side. Probably blue in the living insect. Alar sinuses marked each with a small yellow spot. Metepisternal and metapimeral bands also yellow, the former interrupted at about its middle by a narrow black line.



FIGS. 7–8.—(7) Head of *Melanocypha snellemanni*. (*a*) *javana* ♂; (*b*) *snellemanni* ♂; (*c*) *snellemanni* ♀; (8) (*a*) Pterothorax of *M. snellemanni javana*; (*b*) Abdomen of the same.

Abdomen black, the first segment with a blue mark on either side. Segments 2–7 each with a lateral blue band on either side. This band thicker at the base of the segment and tapers distally, also becoming progressively reduced from segment 5 to 7. In addition segments 2–4 have at the distal end of the side of each of them a fine, blue vertical line, reaching nearly to middorsal line of segment, but not extending to the ventral surface. In these three segments the lateral blue line is continuous with this vertical mark.

Wings.—Fore wing hyaline with a definite yellow tinge up to a point one cell distal to the nodus. Rest of the wing dark, opaque brown, but with a large fenestra occupying middle third of opaque area. This fenestra rather rectangular, and hyaline, not tinged with yellow. Inner margin of opacity not sharply defined and runs transversely across wing. Inner margin of fenestra also not sharply defined, but its outer border clear cut and just a little convex; it is bounded anteriorly by a narrow opaque border between the costa and radius. Opacity also continuous along the hind margin and is one cell deep.

Hind wing hyaline for the first three-quarters of its length from the base, and then abruptly opaque, inner border of the opacity again running transversely. To a level about mid-way between nodus and pterostigma the hyaline area is tinged with yellow; beyond this not tinged and here corresponds closely to fenestra of fore wing. Within the distance of a cell or two of its outer border yellow tinge of basal part of the wing deepens irregularly, marking off the inner side of the fenestra. Whole surface of both wings irridescent; the fenestrae especially so.

Legs entirely black.

Anal appendages black.

This new subspecies is readily distinguished from the Sumatran race by the entirely orange nasus, and by the differences in the colour-pattern of the wings. The antehumeral band on the thorax of *javana* is relatively broader, rather dilated, narrowing above, whilst the Sumatran form has the band of equal width throughout. In both races the humeral line is reduced to a small upper trace.

The specimens examined by me are not in very good condition for description. They will be returned to the British Museum. I have selected one of them as the type of *Melanocypha snellemanni javana*.

Mr. Lieftinck has very kindly given me the following notes:

" In MacLachlan's day the Priangan District was still virgin country, but nowadays the District is almost entirely under cultivation, being the centre of the rubber and tea cultures (not to mention cinchona at higher elevations). It is also the most densely peopled region of Java, except perhaps Djokjakarta and the Solo District of Central Java. The new race may turn up again somewhere in Bantam in W. Java, but I fear there will be no more opportunity for me to visit there."

"In Sumatra both sexes keep very close to the surface of the water, and are strictly confined to those spots in a stream where the water splashes between the bigger stones and boulders.

" The dancing males are wonderful creatures. When hovering they show two brilliant, emerald semicircles, sharply contrasted with the deep blackish brown of the surrounding opaque areas of the wings."

The female of the Sumatran race has not been described. I give below an account of a specimen very kindly given me by Lieftinck.

The specimen from Pendeng, N. Sumatra (Atjeh), was collected in 1937 by A. Hoogerwerf, and will be deposited in the British Museum.

Melanocypha snellemanni snellemanni ♀ (Allotype ♀).

Head black, the anterior surface of the nasus and a pair of oblong spots on its dorsal surface yellow. On the frons a pair of rectangular marks of the same colour, and a smaller pair close behind these at base of antennae. In addition, a pair of small spots one on either side of the posterior ocelli, a small median spot at the occipital angle, and a pair, one on each side of the epicranium are yellow.

Prothorax black, marked with chrome yellow as follows: A fine marginal line along the anterior margin of the notum, a spot on either side of middle lobe of notum, and small median and lateral spots on posterior lobe.

Pterothorax black. Mid-dorsal carina finely lined with yellow, paired yellow antehumeral stripes, humeral suture finely marked with yellow. Lateral markings as in the male. Under surface whitish.

Abdomen black. A fine yellow line along mid-dorsal carina from segments 1–7; 9 with distal yellow spot. Segment 1 marked with yellow at sides, whilst 2–8 have each a basal and apical, yellow spot, the basal spot rather elongate, coalescing with apical spot on segments 2–4. Tergites 1–9 finely margined with yellow below.

Wings hyaline, rather smoky. Pterostigmata black.
Legs black, anterior surfaces of coxae and of extreme upper end of femora yellowish.
Anal appendages black.
Length of hind wing 24 mm., of abdomen 17 mm.

APPENDIX II.

A list of all specific and subspecific names proposed for forms of the genus Rhinocypha, *with the names under which they are listed in this survey.*

The full synonymy would take up a great deal of space, but I have been at pains to make the list full and reliable. I have again to thank Col. Fraser, Mr. Cowley and Mr. Kimmins for their help.

abbreviata Fraser, 1928—*Heliocypha biforata abbreviata.*
adamantina Forster, 1903—*Aristocypha cuneata.*
albistigma Selys, 1873—*Rhinocypha albistigma.*
albistigma Matsumura, 1931 (nec Selys)—*Heliocypha perforata perforata.*
amanda Lieftinck, 1938—*Rhinocypha tincta amanda.*
anambae Laidlaw, 1932—*Heliocypha biseriata anambae.*
angusta Selys, 1853—*Heliocypha angusta angusta.*
anisoptera Selys, 1853—*Rhinocypha anisoptera.*
apicalis Krüger, 1898—*Heliocypha angusta angusta.*
apicalis Laidlaw, 1903 (nec Kruger)—*Heliocypha perforata limbata.*
aurofulgens Laidlaw, 1931—*Rhinocypha aurofulgens.*
aurulenta Forster, 1903—*Rhinocypha aurulenta.*
baibarana Matsumura, 1931—*Aristocypha fenestrella.*
beatifica Fraser, 1927.—*Heliocypha perforata beatifica.*
beesoni Fraser, 1923—*Heliocypha biforata biforata.*
bifasciata Selys, 1879—*Aristocypha bifasciata.*
bifenestrata Fraser, 1922—*Aristocypha quadrimaculata.*
biforata Selys, 1859—*Heliocypha biforata biforata.*
biseriata Selys, 1859—*Heliocypha biseriata biseriata.*
bisignata Selys, 1853—*Heliocypha bisignata.*
braueri Krüger, 1898—*Rhinocypha sumbana.*
cognata Kimmins, 1936—*Rhinocypha cognata.*
colorata Selys, 1869—*Rhinocypha colorata.*
cornelii Lieftinck, 1948—*Heliocypha fenestrata cornelii.*
cucullata Selys, 1873—*Rhinocypha cucullata.*
cuneata Selys, 1853—*Aristocypha cuneata.*
cuneata Needham, 1930 (nec Selys)—*Aristocypha fenestrella.*
delimbata Selys, 1879—*Heliocypha biforata delimbata.*
dentiplaga Lieftinck, 1939—*Rhinocypha tincta dentiplaga.*
drusilla Needham, 1930—*Rhinocypha drusilla.*
eximia Selys, 1873—*Rhinocypha eximia.*
fenestrata Burmeister, 1839—*Heliocypha fenestrata fenestrata.*
fenestrella Rambur, 1842—*Aristocypha fenestrella.*
frontalis Selys, 1873—*Rhinocypha frontalis.*
fulgidipennis Selys, 1853—*Aristocypha fulgipennis.*
fulgipennis Guerin, 1831—*Aristocypha fulgipennis.*
hageni Krüger, 1898—*Rhinocypha hageni.*
hemihyalina Fraser, 1921—*Aristocypha quadrimaculata.*
heterostigma Rambur, 1842—*Rhinocypha heterostigma heterostigma.*
hilaryae Fraser, 1927—*Aristocypha hilaryae.*
humeralis Selys, 1873—*Rhinocypha humeralis.*
ignipennis Selys, 1879—*Rhinocypha ignipennis.*
immaculata Selys, 1879—*Aristocypha immaculata.*
inas Laidlaw, 1902—*Heliocypha perforata limbata.*
infumata Rambur, 1842—*Heliocypha fenestrata fenestrata.*

io Fraser, 1926—*Rhinocypha heterostigma io.*
iridea Selys, 1891—*Aristocypha iridea.*
karschi Krüger, 1898—*Sundacypha petiolata.*
katharina Needham, 1930—(Sp. delend. *Euphaea* sp.)
kerri Fraser, 1933—*Aristocypha kerri.*
laidlawi Fraser, 1924—*Calocypha laidlawi.*
liberata Lieftinck, 1949—*Rhinocypha liberata.*
limbata Selys, 1879—*Heliocypha perforata limbata.*
maculata Matsumura, 1931—*Heliocypha perforata perforata.*
mariae Lieftinck, 1930—*Heliocypha mariae.*
monochroa Selys, 1873—*Rhinocypha monochroa.*
moultoni Laidlaw, 1916—*Rhinocypha moultoni.*
nubecula Lieftinck, 1948—*Heliocypha nubecula.*
oceanis Lieftinck, 1948—*Heliocypha angusta oceanis.*
ogasawarensis Oguma, 1913—*Rhinocypha ogasawarensis.*
pagenstecheri Forster, 1897—*Rhinocypha pagenstecheri.*
pallidifrons Ris, 1927—*Rhinocypha pallidifrons.*
pelops Laidlaw, 1936—*Rhinocypha pelops.*
perforata Percheron, 1835—*Heliocypha perforata perforata.*
petiolata Selys, 1859—*Sundacypha petiolata.*
petiolata Brauer, 1867 (nec Selys)—*Rhinocypha ustulata.*
phantasma Lieftinck, 1935—*Rhinocypha phantasma.*
quadrimaculata Selys, 1853—*Aristocypha quadrimaculata.*
quattuordecimmaculata Oguma, 1914—*Heliocypha perforata perforata.*
retrograda Lieftinck, 1938—*Rhinocypha tincta retrograda.*
rutilans Rambur, 1842—(Sp. delend. *Chalcopteryx.*)
sagitta Lieftinck, 1938—*Rhinocypha tincta sagitta.*
selysi Krüger, 1898—*Rhinocypha selysi.*
semitincta Selys, 1869—*Rhinocypha tincta semitincta.*
spuria Selys, 1879—*Aristocypha spuria.*
stygia Forster, 1897—*Rhinocypha stygia.*
sven-hedini Sjöstedt, 1932—*Indocypha svenhedini.*
terminata Selys, 1869—*Rhinocypha ustulata.*
tincta Rambur, 1842—*Rhinocypha tincta tincta.*
trifasciata Selys, 1853—*Aristocypha trifasciata.*
trimaculata Selys, 1853—*Rhinocypha trimaculata.*
turconii Selys, 1891—*Rhinocypha turconii.*
unicolor Selys (Hagen), 1869—*Cyrano unicolor* (*Libellago asiatica* Selys).
unimaculata Selys, 1853—*Paracypha unimaculata.*
ustulata Brauer, 1867—*Rhinocypha ustulata.*
whiteheadi Kirby, 1900—*Heliocypha perforata perforata.*
whiteheadi Laidlaw, 1917 (nec Kirby)—*Heterocypha vitrinella.*
whiteheadi Fraser, 1934—*Heterocypha vitrinella.*
vitrella Rambur, 1842.—*Heliocypha angusta angusta.*
vitrinella Fraser, 1935—*Heterocypha vitrinella.*
xanthe Ris, 1927—*Rhinocypha xanthe.*

SUMMARY.

An account is given of the history and classification of the CHLOROCYPHIDAE based largely on the evidence supplied by the geographical distribution of existing forms.

It is suggested that the family originated in the lands of the "Sunda Shelf" in Tertiary times, and that migrations from the main stock starting at different levels in time, succeeded in colonizing Tropical Africa, the Asiatic mainland, and Papua.

The classification is discussed, and an annotated list of genera given; three new genera are proposed. Recorded species are listed.

An appendix gives a description of a new geographical species of *Melanocypha* from Java. A second appendix lists all specific and sub-specific names hitherto proposed for the genus *Rhinocypha*, and gives the generic position here adopted.

POSTSCRIPT.

Lieftinck has very recently described a distinct new genus belonging to the Libellagine series. This is *Pachycypha* with a single species from S.E. Borneo. (Lieftinck, M. A., 1950, *Treubia*, **20** : 631–638.) Fraser has also just published additions to his *Revision* including description of a new species of *Platycypha* from Tanganyika Territory, and further notes on species of *Chlorocypha*. A description of a second new species of *Platycypha* also from Tanganyika Territory is added to the same paper by Pinhey. (Fraser, F. C., 1950, *Bull. Inst. roy. Sci. nat. Belg.* **26** : 1–22).

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(This is not a complete list. I have not given references previous to the date of Kirby's *Catalogue of Odonata* (1890).

For Fraser's papers dealing with Indian and Ceylanese species described by him I have referred only to his volume in the *Fauna of British India* series dealing with the CHLOROCYPHIDAE, as he gives there a very full bibliography.

Similarly, for the African species of the family I refer only to his recent *Revision* for the full synonymy of all the African species named up to 1949.)

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THE *ANOPHELES UMBROSUS* GROUP (DIPTERA: CULICIDAE).

PART I: SYSTEMATICS, WITH DESCRIPTIONS OF TWO NEW SPECIES.

By J. A. REID.

PART II: BIOLOGY AND TRANSMISSION OF MALARIA.

By E. P. HODGKIN.

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With 15 Text Figures.

PART I: SYSTEMATICS, WITH DESCRIPTIONS OF TWO NEW SPECIES.

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1. INTRODUCTION AND ACKNOWLEDGMENTS.

GATER (1935), in his valuable handbook on the *Anopheles* of Malaya, says of *umbrosus*, "it is uncertain, however, if the form described conforms to Theobald's type, and there are other forms which differ from it. The group requires revision." I became interested in this group of species in 1940, when I discovered specimens of what is here named *roperi*, and realized that they belonged to a distinct species. The invasion of Malaya by the Japanese put a stop to the work. Fortunately the specimens and notes survived, so that it was possible to resume with the minimum of delay. I have been encouraged to find that in a number of respects my views on this group agree well with those of Colless (1948).

The *Anopheles* (*Anopheles*) *umbrosus* group is here defined as those species in the series *Myzorhynchus* without, or with only a few developed palmate hairs on the abdomen of the larva, i.e. the branches of these hairs are not flattened into leaflets, but are filamentous like those of the other larval hairs.

The *Myzorhynchus* series of *Anopheles* is rather characteristic of the Malaysian sub-region (Reid, 1950), and the *umbrosus* group forms an important and highly endemic part of this series. In addition the group contains at least two important vectors of malaria, so that the need for a sound understanding of these species requires no emphasis. The systematics of the group has been much confused because of the very close superficial similarity of the adults, with their subdued markings (*vide* Buxton, 1938 : 59). However, close study of the adults as well as the larvae and pupae reveals no lack of clear-cut specific characters, so that the status of these forms as distinct species is not in doubt; they are not sibling species like the forms of *Anopheles maculipennis*.

A few words may be said on the principal characters of diagnostic value. In the adults: the palps and proboscis of the female, whether ornamented, shaggy and of what length. In both sexes the thoracic setae, especially the presence or absence of propleurals, are important, as are certain wing markings; these are the markings on costa, remigium, and veins 1, 5 and 6 in the basal third of the wing, and the markings on the rest of the costa and vein 1, together with the apical fringe spots. The width and distribution of the pale bands on the fore and hind tarsi. The leaflets of the male genitalia, but not much else. In the larva: the clypeal hairs; the antennal hairs; the ventral sabre piece of the antenna; the presence or absence of any developed abdominal palmate hairs. In the pupa: the respiratory trumpet, which is quite characteristic of each species, and has a well-marked secondary lobe for which the term "tragus" is proposed; the presence or absence of projecting flanges or bosses on the ventro-lateral angle of the dorsal plate below the root of the trumpet, and on the wing case: the shape of the lateral abdominal spines; the breadth of the paddles and pigmentation of their bases. The eggs have not been studied.

ACKNOWLEDGMENTS.

This account is based largely on specimens in the collection of this Institute (I.M.R.)[1], but also on specimens seen in the collection at the British Museum (Nat. Hist.) (Mr. H. Oldroyd) (B.M.), including Theobald's type of *umbrosus*, and in the collection at the Institute for Tropical Hygiene, Amsterdam (Prof. N. H. Swellengrebel and the late Prof. S. L. Brug)(B.). I wish to thank these gentlemen, and the Keeper of Entomology at the British Museum, Mr. N. D. Riley, for their very kind help. I owe very much to my predecessor at this Institute, Mr. E. P. Hodgkin, and his staff, who built up the fine collection which I have been able to study and add to. I also wish to thank Mr. D. H. Colless for kindly presenting specimens from Borneo and patiently waiting for me to complete this paper. I was greatly assisted by the grant of study leave and travelling expenses from the Malayan Government.

2. KEYS TO THE SPECIES OF THE *Anopheles umbrosus* GROUP.

Anopheles hunteri Strickland and *similissimus* Strick. have not been included in these keys as they are insufficiently known. Many of the characters used in the keys are illustrated by figures in the text. The terminology employed by Christophers (1933) has been used throughout.

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[1] The letters in brackets following the names of the collections are the abbreviations used in the text to indicate the location of the specimens seen.

Adults.

1. Wings unspotted; whole insect quite unornamented, culicine-like. Palps thin and shorter than proboscis . . . . *brevipalpis* Roper.

–. Not so . . . . 2.

2. Palps with obvious pale bands, especially at the tips. Wings brightly marked; somewhat resembles *hyrcanus* . . . . *separatus* Leicester.

–. Palps entirely dark. Wings sombre with few pale markings . . . 3.

3. With propleural setae . . . . 4.

–. Without propleural setae . . . . 6.

4. Proboscis and palps of female short, about three-quarters as long as the fore femur. Fore tarsi with first and second pale bands three to four times as long as wide, extending a little below the joints. Cross vein 3–4 level with Sc pale spot on costa. Leaflets of phallosome serrate *brevirostris* sp. n.

–. Proboscis and palps as long as fore femur. Pale bands on fore tarsi, if present, small, not longer than wide, not extending below the joints. Cross vein 3–4 usually posterior to Sc pale spot. Leaflets of phallosome not serrate . . . . 5.

5. Fore and hind tarsi with pale bands, those of the hind tarsi from one to three times as long as wide. Basal dark mark on vein 5 extending half way or more to the fork. Subalar setae 1–6, without associated scales . . . . *umbrosus* Theobald.

–. Tarsi entirely without pale bands, or with minute ones rarely as long as wide. Basal dark mark on 5 not extending half way to the fork. Subalar setae 9–19, nearly always with one or two associated scales *baezai* Gater.

6. Wing with three apical fringe spots, and pale scales on the extreme base of 5, the base of 1 and the remigium, and usually on the extreme base of the costa. Median and lateral areas of the mesonotum with a mottled grey pattern. Upper sternopleural setae 7–17; coxae with scales. Base of hind tibia with a pale band one and a half to three times as long as wide. Leaflets of phallosome curved, strap-shaped, about fifteen times as long as wide . . . . *roperi* sp. n.

–. With only two apical fringe spots and no pale scales on the base of 5, 1, remigium or costa. Median area of mesonotum uniform ashy grey, lateral areas dark. Upper sternopleural setae 3–6; coxae without scales. Base of hind tibia without pale band. Leaflets of phallosome blade-shaped, about eight times as long as wide . . *letifer* Gater.

Larvae.

1. Palmate hairs with developed leaflets on at least two segments, IV and V . . . . 2.

–. Palmate hairs undeveloped. No leaflets on any segments . . . . 3.

2. With a stigmal club. Posterior clypeal hairs small, not reaching bases of inner. Ventral sabre piece of antenna obliquely truncate, not spinous apically . . . . *umbrosus*.

–. No stigmal club. Posterior clypeal hairs large, reaching to or beyond bases of inner. Ventral sabre piece of antenna spinous apically *brevirostris* sp. n.

3. Terminal antennal hair with one or two of the branches rather stout and hooked . . . . 4.

–. Not so, all branches filamentous . . . . 6.

4. Posterior clypeal hairs large, with 1–9 branches, reaching to or beyond bases of inner. Inner often dividing towards the tip into 2 or 3 more or less equal branches, outer with 7–13, av. 10 . . . *brevipalpis.*
–. Posterior clypeals smaller, not reaching bases of inner; 2–4 branches. Inner simple, occasionally with a few fine branches at the tip; outer 4–7, av. 5 or 6 . . . 5.
5. Lateral hair on III with 13–20 branches, av. 17, hair 0 on III, 3–4 . *letifer.*
–. Lateral on III, 21–26, av. 23; hair 0 on III, 5–6 . . . *roperi* sp. n.
6. Tips of inner clypeals frayed into small fine branches. Antennal hair 13–21, lateral on IV, 7–10 . . . *baezai.*
–. Inner clypeals simple, antennal bushy, 25–36, lateral on IV, 3–4 *separatus.*

Pupae.

These are readily identified from the shapes of the respiratory trumpets (see figures), which are difficult to describe. The key below is offered only as an additional guide, and to some extent as an indication of affinities.

1. Paddles nearly as wide as long. With a pigmented flange or boss at the root of the trumpet (ventro-lateral angle of the dorsal plate) and one or two on the wing case . . . 2.
–. Paddles from two-thirds to three-quarters as wide as long. Without such pigmented projections . . . 4.
2. Paddle base strongly pigmented. Branched lateral spine of VIII set back from the apex of the segment . . . *brevipalpis.*
–. Paddle base not, or only faintly pigmented. Lateral spine of VIII on the apex of the segment . . . 3.
3. Tragal lobe of trumpet complexly folded. Sides of male genital pouch convergent . . . *letifer.*
–. Tragus fairly simple, spatulate. Sides of male genital pouch parallel *roperi* sp. n.
4. Paddle base strongly pigmented . . . 5.
–. Paddle base not pigmented . . . 6.
5. Tragus broadly spatulate. Rim of pinna with two thickened and pigmented areas . . . *separatus.*
–. Tragus narrow. Rim of pinna without such thickenenings *brevirostris* sp. n.
6. Lateral spine on V pointed, 4 to 6 times as long as wide. Posterior margins of tergites with teeth . . . *umbrosus.*
–. Lateral spine on V rounded, about twice as long as wide. Tergites without teeth . . . *baezai.*

3. DESCRIPTIONS.

Anopheles (*Anopheles*) *umbrosus* Theobald, 1903.

Type locality : Pekan, Pahang, Malay Peninsula.

Type : ♀ in Brit. Mus. (Nat. Hist.).

Nec *A. umbrosus* Stanton, 1912, 1912*a*, 1915; Puri, 1931, and Gater, 1934 and 1935 (= *letifer*). ? In part of Swellengrebel and Rodenwaldt, 1932, and Christophers, 1933.

Synonym : *novumbrosus* Strickland, 1916*b*.

Adult ♀.

A large black anopheline with an ashy grey mesonotum.

Head.—Proboscis dark, rather shaggy towards the base; length 1·9–2·2, av. 2·1 mm., very slightly shorter than fore femur; ratio fore femur/proboscis = 1·07. Palps all dark, shaggy, shorter than proboscis by about the length of the labellum. Clypeus dark, without scales. Antennae with a few dark scales on posterior face of torus and a small tuft of dark scales on first flagellar segment. Vertex narrow with pale setae and scales ; a median patch of white scales on the occiput ; remaining head scales dark.

Thorax.—When viewed from above at a suitable angle, with a broad ashy, or blue grey, pruinose band occupying the median area of the mesonotum, and contrasting with the very dark lateral areas. Anterior scales of mesonotum dark laterally, with a few narrow, pale median ones. Pronotal lobes with dark scales. Scutellum grey, conforming with the median area of mesonotum. Pleurae dark with some greyish pruinose areas, without scales. Setae : Propleural, 2–6, av. 4·1 ; sternopleural, upper, 2–4, av. 2·5 ; lower, 3–6, av. 4·8 ; spiracular, 4–7, av. 5·3 ; prealar, 7–11, av. 9·0 ; subalar, 1–6, av. 3·5. The subalar setae are dark and strong and usually placed in one row (fig. 1*a*) ; there are no scales associated with them.

Legs.—Dark above, paler beneath, with narrow tarsal pale bands. Coxae without scales, except for an occasional one on the fore coxa. Upper mid coxal setae, 3–7, av. 4·3. Fore tarsi with narrow apical pale bands (40/40), the first the longest, about as long as wide, fourth the smallest (fig. 2*a*). Mid tarsi similar, but the pale bands generally slightly narrower. Hind tarsal pale bands (fig. 2*f*) mainly apical, but occasionally spreading a little on to the lower sides of the joints, especially the third band. First and second pale bands from about as long as wide to three times as long, always mainly above the joints (40/40). Tibio-tarsal joints, especially of the hind leg, often with a small pale fleck.

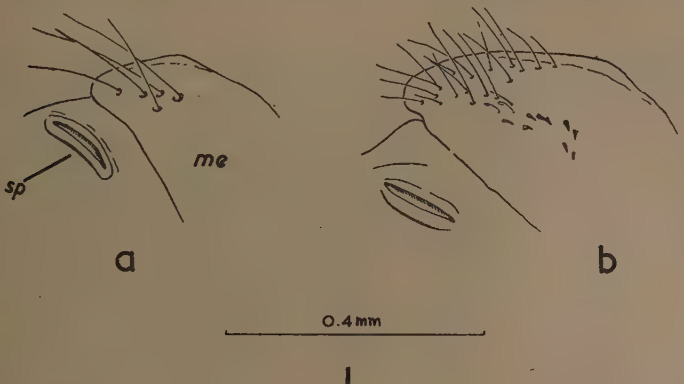

FIG. 1.—Subalar (mesepimeral) setae. (*a*) *umbrosus*, (*b*) *baezai*. Symbols : *me*, mesepimeron ; *sp*, metathoracic spiracle.

Wings (fig. 3*a*).—Length 3·4–4·1, av. 3·8 mm. The costa and vein 1 are densely clothed with black scales, and together form a rather pronounced black margin along the wing. Costa to termination of vein 1 entirely dark except for a small subcostal pale spot present in about half of Malayan specimens (28/50) and most Bornean specimens (11/11). Remigium all dark, humeral cross vein with a small tuft of dark scales. Subcosta dark except for a few pale scales sometimes present at extreme tip, forming part of the subcostal pale spot. Vein 1 all dark except for tip, and a few (up to 7) pale scales representing the sector pale spot, present in about half the specimens (13/25). Two apical fringe spots always present, one at termination of vein 1, the other between 2.2 and 3. The pale mark towards the base of 2.2 often somewhat obscure, or if well defined, one quarter or less the length of 2.2 (10/11). Basal dark mark on 5 extending half way or more to the fork of 5. No pale scales at extreme base of 5. Vein 6 usually (20/25) with a few (up to 10) scattered darkish scales in the basal half above the upper dark mark; sometimes these are represented by two or three at the extreme base. Cross vein 3–4 posterior to subcostal pale spot (11/11).

Abdomen.—Dark, entirely without scales.

Adult ♂.

In general similar to female.

Terminalia (fig. 5*a–c*).—Phallosome long, about half the length of the coxite, with about eight pairs of very long slender thread-like leaflets which at once distinguish this species, the longest as long as or longer than the phallosome. Parabasal spines abnormal in two out of the three specimens examined, either the inner or outer spines duplicated. Ventral lobe of harpago with one large spine and one much smaller, sometimes with a third minute spine.

Larva.

(See Appendix, Table III.)

Usually somewhat pinkish brown. Distinguishing characters: Anterior fan-shaped plate of spiracular apparatus produced into a "stigmal club" like that of *pseudobarbirostris* illustrated by Russell and Baisas (1934, fig. 5, and pl. 33, fig. 11), but tapering to a fine point, not clubbed. This stigmal filament in *umbrosus* is illustrated by Hodgkin (1945, p. 14), whose drawing shows it directed anteriorly; usually in mounted specimens it is directed posteriorly between the spiracles, whilst in living larvae it is erect, and with a hand lens can often be seen breaking the surface film of the water. Fully developed pigmented palmate hairs only on two segments of the abdomen, IV and V; those on segment VI with narrow lanceolate leaflets, on III and VII rudimentary, on I and II weak hairs with ordinary filamentous branches. Often even the palmates on IV and V are weak and not pigmented and are then difficult to see. Outer clypeal hairs with 10–22 branches, average 14. Ventral sabre piece of antenna obliquely truncate and very slightly frayed at tip (fig. 7*d*). Prothoracic hair 4 with a concentration of short branches at the tip, giving a somewhat spatulate and tufted appearance (fig. 8*a*); branches on the stem of the hair outstanding and of moderate length. For further details of the larva of this and the subsequent species see Appendix, Table III.

Pupa.

It has been found that the shape of the respiratory trumpet is very characteristic of each of the species dealt with in this paper (see figs. 9–11). The pinna of the trumpet always has a well marked secondary lobe, for which the term *tragus* is suggested, so as to carry on the analogy with the human ear. The form of the trumpet, together with certain other features, is so characteristic that living pupae can be easily identified with a low power binocular microscope.

A. umbrosus (fig. 9*a*, 12*b*, 13*a–c*).—Without lateral flanges on the cephalothorax (see *brevipalpis*, p. 307), trumpets in the living pupa not meeting in the mid-dorsal line. Tragus narrow, trough-like, abruptly twisted apically. Posterior margins of tergites with teeth, lateral spine on segment V pointed, about 4–6 times as long as broad. Paddle about two-thirds as wide as long, not pigmented. The pupa described by Crawford (1938) as *umbrosus* is that of *letifer*.

For other illustrations of this species see the following: *adult* ♀, Colless, 1948, fig. 9; ♂ *terminalia*, Christophers, 1933, fig. 26/4, Colless, fig. 9; *larva*, Gater, 1934, p. 101, Hodgkin, 1945, p. 14 (*novumbrosus*), Colless, fig. 9.

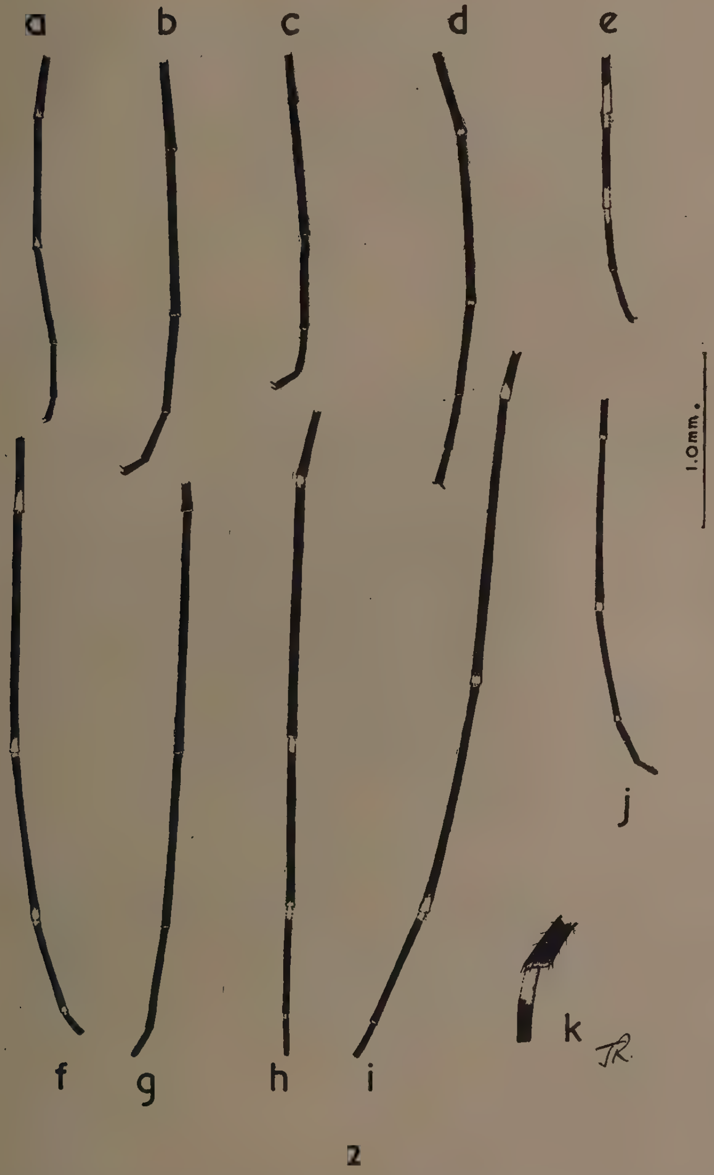

FIG. 2.—Fore and hind tarsi. (*a, f*) *umbrosus*, (*b, g*) *baezai*, (*c, h*) *letifer*, (*d, i*) *roperi*, (*e, j*) *brevirostris*, (*k*) base of hind tibia, *roperi*.

Identification.

The presence of propleural setae and pale bands on the fore tarsi, together with the apical position of the hind tarsal bands, distinguishes *umbrosus* from *letifer*. The key shows the characters distinguishing it from *baezai*. The larvae are readily identified by the presence of the stigmal filament, and by the palmate hairs on IV and V, if these are pigmented.

Distribution.

The distribution known so far, based on examination of specimens, is Malay Peninsula, Sumatra and Borneo. This agrees with Brug and Bonne-Wepster (1947, *novumbrosus*).

Notes.

Examination of the type of *umbrosus* Theobald, 1903, showed that it belongs to the species hitherto identified in Malaya as *novumbrosus* Strickland, 1916, which therefore becomes a synonym. The type specimen of *umbrosus*, labelled "Pekan hospital, Pahang, October, 1902, Dr. Durham," shows the following characters which clinch the identification: Propleural setae, 2 and 3; subalar setae few, strong and dark, placed as in fig. 1*a*; no associated scales; hind tarsal pale bands predominantly apical, from once to twice as long as wide. Stanton (1912, 1912*a* and 1915) described larvae, distinguished by the absence of any palmate hairs, as those of *umbrosus* Theobald, because the resulting adults appeared to be that species. Strickland (1916*b*) found larvae which also produced *umbrosus*-like adults, but which were quite distinct from Stanton's larvae in having fully developed palmate hairs on IV and V; he therefore named them as a new species *novumbrosus*. We now know that Stanton's larvae (Stanton, 1915, fig 15) were almost certainly those of what is here called *letifer* Gater, 1944, and not of *umbrosus* Theobald. The very close similarity in external appearance among the adults of the *umbrosus* group has caused great confusion, and Strickland (1916*b*), in attempting to find differences between them, appears to have been dealing with a completely mixed series of specimens. However, his description of the larvae of *novumbrosus*, in particular of the condition of the palmate hairs on each segment, makes it clear that he had the larvae of *umbrosus* and not those of any of the other species described here. Colless (1948 : 92) has independently reached the same conclusions on the synonymy of *novumbrosus* and *umbrosus*. Leicester (1908) describes *umbrosus* from a single specimen caught in the jungle near Kuala Lumpur. It may be assumed from his description that the specimen was *umbrosus* Theobald, since the absence of a subcostal pale spot on the costa rules out the other commoner species except *baezai*, and the presence of tarsal pale bands coupled with the inland locality rules out *baezai* also.

Puri's description (1931) of the larva of *umbrosus*, based on specimens sent from Malaya, is a description of *letifer*.

Specimens seen.[2]—MALAY PENINSULA: (B.M.), Perak, 1913, 1 ♀ (*A. T. Stanton*), Taiping, 1899, 1 ♀ (*L. Wray*, jun.); Pahang, Pekan Hospital, x.1902, 1 ♀ (the type) (*Dr. Durham*); Selangor, jungle patch one mile from Klang, 29.xii.1903, 1 ♀ (*G. F. Leicester*). (I.M.R.), Province Wellesley, Simpat estate, 27.iv.34, 1 ♂ (*E.P.H.*); Pahang, Kuantan, 23.iii.49, 1 ♀ day-biting

---

[2] E.P.H. = E. P. Hodgkin; J.A.R. = J. A. Reid.

(*J.A.R.*); Selangor, Kuala Kubu Bahru, 4.iv.41, 1 ♂ (*J.A.R.*), Kampong Sijangkang, 14.xii.42, 6 ♀ (*P. D. Rajamoney*), 7.v.48, 8 ♀ (*J.A.R.*), Sepang estate, 29.xii.32, 3 ♀, caught biting (*E.P.H.*), Bukit Cheeding estate, 1936–48, many specimens, Klang, 14.xii.42, 3 ♀, Olah Limpit, 19.x.42, 2 ♀, 22.ii.43, 18 ♀ day-biting (*P. D. Rajamoney*).

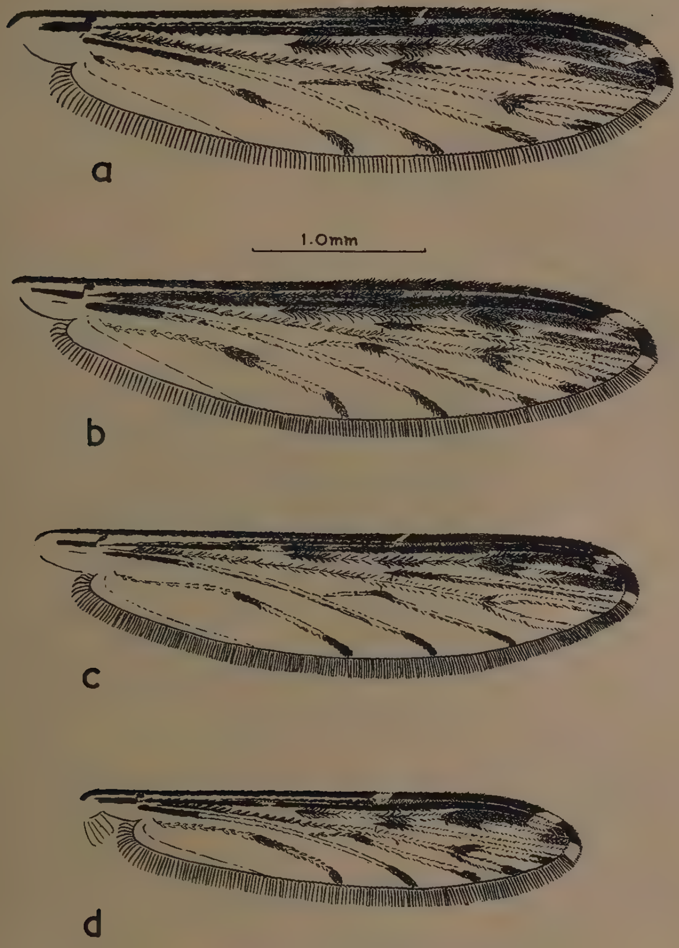

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FIG. 3.—Wings. (*a*) *umbrosus*, (*b*) *baezai*, (*c*) *letifer*, (*d*) *brevirostris*.

Sumatra (B.): Sibolga, 1 ♀, Singkel, 2 ♀, Rantau Panjang, 1917, 3 ♀ (*Swellengrebel*).

Borneo: (B.M.), Sarawak, 1908, 2 ♀ (*J. Hewitt*), ? Kuching, 1914, 1 ♀ (*J. C. Moulton*); N. Borneo, Membakut, Mawao estate, 1914, 1 ♀, 1 ♂ (*Roper*). (I.M.R.), Brunei, Kuala Belait and Seria, vii and viii.45, 6 ♀, 1 ♂ (4 ♀ day-biting) vi.48, 4 ♀ (*D. H. Colless*).

Anopheles (*A.*) *baezai* Gater, 1933.

Type locality: Langkawi islands, Malay Peninsula.

Type: ♂ and ♀, larval pelt and larva in Brit. Mus.

Synonym: *gateri* Baisas, 1936. "*umbrosus* larval variation" Swellengrebel and Sw. de Graaf, 1919.

Adult ♀.

Very closely resembles *umbrosus*, but differs as follows:

Head.—Dark scales on antennal torus more numerous, visible dorsally when the head is viewed from in front (25/25); not so in *umbrosus*, which tends, however, to have slightly more scales on the first flagellar segment. Proboscis 2·1–2·4, av. 2·3 mm.; ratio fore femur/proboscis = 1·01.

Thorax.—Setae: Propleurals, 1–3, av. 2·6; sternopleural, upper, 3–6, av. 4·6, 3/14 with one scale amongst the setae; lower, 3–6, av. 3·9; spiracular, 3–5, av. 3·7; prealar, 9–12, av. 10·8; subalar, 9–19, av. 13·5, 19/21 with 1–7 associated scales, av. 2·6 scales. The subalar setae and scales form a good character for distinguishing this species from *umbrosus* (see fig. 1*b*). The setae are much more numerous and are in several rows; some are dark and strong, others weak and pale; they extend much further antero-ventrally, and almost always a few scales are present. The propleural setae are fewer. The upper sternopleurals are usually more numerous, or the same in number as the lower (14/14); in *umbrosus* the upper ones are usually fewer than the lower (9/10).

Legs (fig. 2*b*, *g*).—Tarsi without pale bands, or only with very minute ones. Exceptional specimens with fairly well marked tarsal pale bands may be encountered. Coxae (14/20) often with one or two inconspicuous scales. Upper mid coxal setae, 1–5, av. 2·9. Fore tarsi with very minute pale flecks at the joints (30/40) not quarter as long as wide, or with none (10/40). Mid tarsi entirely unbanded (27/40), or with very minute pale flecks at the joints (13/40). Hind tarsi with very minute pale bands at the joints, rarely as long as wide. Extreme apex of hind tibia usually slightly pale.

Wings (fig. 3*b*).—Length, 3·7–4·3, av. 4·0 mm. Almost identical with the wing of *umbrosus* except for the following. Subcostal pale spot indicated on the costa in less than one third of Malayan specimens (14/50), and in about two-thirds of Bornean (4/6). Vein 1 usually (24/25) with a few pale scales (1–7) representing the sector pale spot. Basal dark mark on vein 5 much shorter, with more scattered dark scales distal to it. If the distal end of this mark is taken to be where it breaks into scattered dark scales, then it does not reach half way to the fork of 5, and sometimes (6/25) reaches only one-third of the way. Fewer specimens (15/26) with scattered dark scales (up to 6) on vein 6 above the upper dark mark.

Adult ♂.

In general similar to the female, being distinguished from *umbrosus* by the same characters.

Terminalia (fig. 5*d*–*g*).—Phallosome less than half as long as coxite; leaflets 4–6 pairs, about one-third length of phallosome, blade-like, not serrated. Ventral lobe of harpago with one long spine, and sometimes a second smaller one of variable length.

Larva.

Blackish, with variable paler marks forming a disruptive pattern. Differs from *umbrosus* principally as follows: Abdomen without any developed palmate hairs; no stigmal process on spiracular plate; lateral hair on abdominal IV with 7–10 branches, 2–3 in *umbrosus*. The following characters are also noteworthy:—Clypeal hairs: *ic* tips finely branched, *oc* 11–25 branches, av. 15·1. Ventral sabre piece of antenna truncate, toothed and frayed at tip (fig. 7*e*). Prothoracic hair 4 as in *umbrosus*.

Pupa (figs. 9*c*, 12*c*, 13*d–f*).

Trumpets wide apart, tragus short. Posterior margins of tergites without teeth. Lateral spine of V short, rounded, about twice as long as broad. Paddle about two-thirds as wide as long, not pigmented. For further description see Baisas (1936).

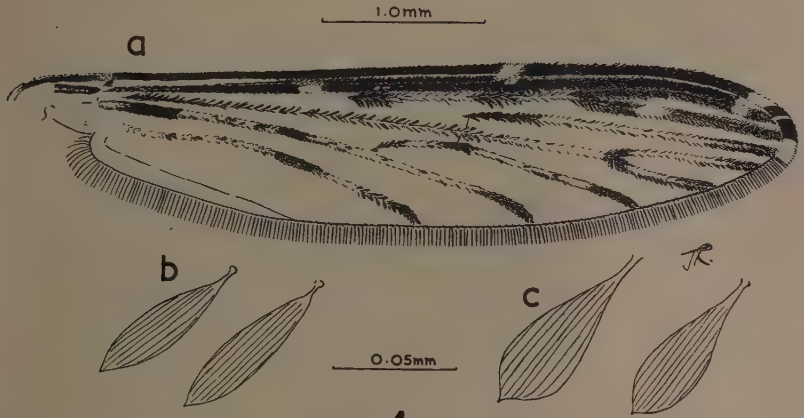

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Fig. 4.—(*a*) Wing of *roperi*; (*b*) *letifer*, scales from the basal third of vein 2.2, upper surface of wing; (*c*) ditto, *roperi*.

For other illustrations of this species see the following: *Adult* ♀, Stanton, 1926, p. 89, drawing by Terzi labelled *umbrosus*, but is more probably *baezai*; Gater, 1933, p. 165, 1935, p. 167, Russell and Baisas, 1936, pl. 5, Colless, fig. 8; ♂ *terminalia*, Gater, 1933, p. 165, Russell and Baisas, pl. 5, Colless, fig. 8; *larva*, Swellengrebel and Sw. de Graaf, 1919, pl. ii, Gater, 1933, pp. 166–168, 1934, p. 93, Russell and Baisas, 1934, pl. 3, Farinaud, 1938, p. 394, Hodgkin, 1945, p. 14, Colless, fig. 8; *pupa*, Baisas, 1936, pls. 3 and 4.

Identification.

The absence of pale bands on any of the tarsi, or their very small size, is usually sufficient, with the presence of propleural setae, to identify *baezai*. The larvae are only found in brackish water, and have more branches (7–10) on the lateral hair of IV than any of the other species (usually 2–4).

Distribution.

Malay Peninsula, Sumatra, Borneo. Java and Celebes (Venhuis *in verbis*). Philippines (Russell and Baisas, 1934), French Indo-China (Farinaud, 1938). Brug and Bonne-Wepster record Java, Celebes and also Bali, but omit to mention the Philippines.

Notes.

The descriptions of the larva and pupa of *A. gateri* Baisas, 1936, do not mention any differences from *baezai*. Colless discusses differences between the adults of the two forms and tabulates three characters, connected respectively with the subcostal spot, the apical costal spot, and the processes of the 9th tergite in the ♂. He concludes that the differences are small, and regards *gateri* (to which he assigns Bornean specimens) as a subspecies of *baezai*. The supposed differences in the shape of the 9th tergite may not be reliable; one Malayan specimen examined had rather short stout processes similar to those described for *gateri*; the character is probably variable and is difficult to use accurately. Gater describes the apical costal spot as extending half way to, or as far as, vein 2.1; this may apply to specimens from the type locality, Langkawi, but none were available for examination. Twenty-five Malayan specimens examined, mostly from Selangor, had this spot in no way different from three specimens from Borneo kindly presented by Mr. Colless; the spot terminated at, or a very little beyond the end of vein 1. In the third character, the percentage of specimens showing a subcostal spot, there does seem to be a real difference, but it is smaller than has been supposed. Gater records only 10 per cent. of Malayan specimens with this spot; Colless finds it present in 80 per cent. of Bornean specimens. Fifty Malayan specimens were examined, and this spot was indicated (at least one or two pale scales breaking the anterior margin of the costa) in 14 (28 per cent.). We may presume, then, that the subcostal spot is present in not less than about 80 per cent. of the Philippine and Bornean specimens, and in about 30 per cent. of the Malayan specimens, but this is the only undoubted difference known at present. Considering also that the habits of both forms are the same so far as known, and are somewhat exceptional (the larvae are found only in brackish water round the coasts), there seems little justification in maintaining *gateri* as a form distinct from *baezai*. Should direct comparison of a large series of specimens from Malaya and the Philippines reveal further and more constant differences, it might then be desirable perhaps to reinstate *gateri* as a subspecies of *baezai*.[3]

There can be little doubt that the *umbrosus* larval variation of Swellengrebel and Sw. de Graaf (1919, pl. 2) is *baezai*, especially as the authors state that the larvae are "always found in brackish or salt water in and near nipah and mangrove swamps." Professor Swellengrebel informs me (*in verbis*) that Dutch workers assume the identity of the two forms. Swellengrebel and Sw.

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[3] I have seen a larval and a pupal skin of what is probably a distinct species related to *baezai*. Material of this form was collected by L. E. Rozeboom on Samar, Philippine Islands, and will be described by him in due course. It cannot very well be *gateri* since the larvae of this are indistinguishable from those of *baezai*, whilst the undescribed form has distinctive larval characters.

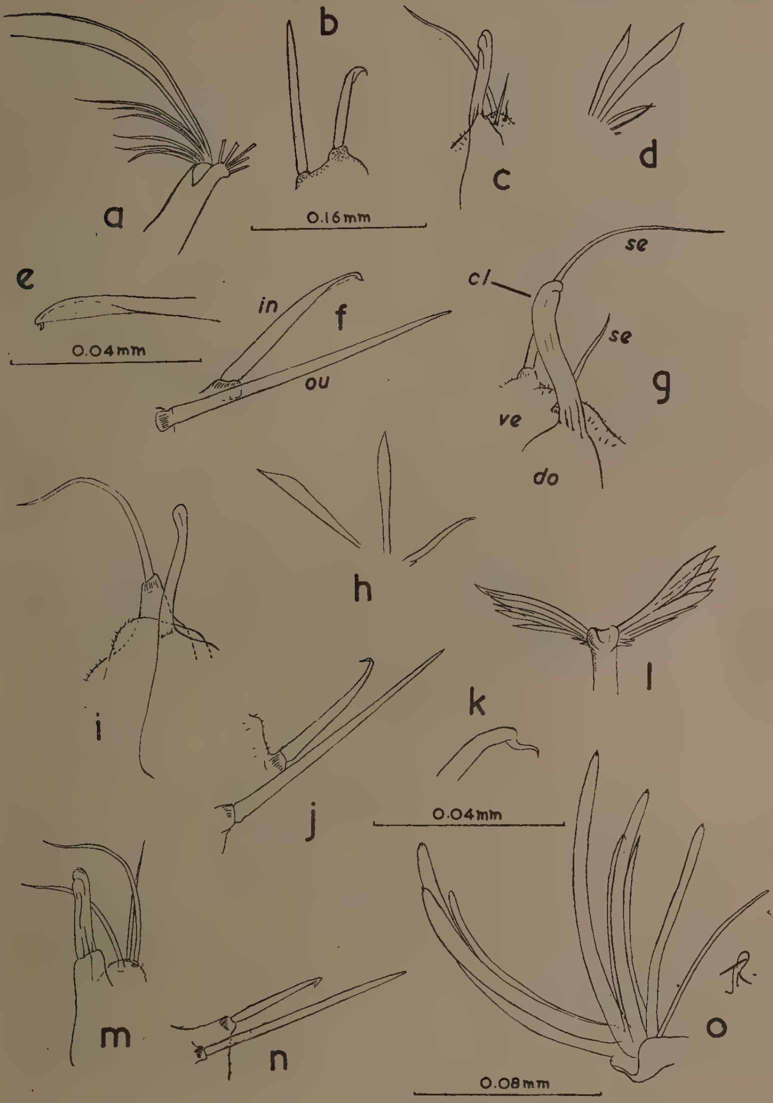

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Fig. 5.—Male terminalia. *umbrosus :* *a*, tip of phallosome with leaflets of one side ; *b*, parabasal spines ; *c*, harpago. *baezai :* *d*, leaflets ; *e*, tip of inner parabasal spine to show hooked and hooded shape common in the *umbrosus* group ; *f*, parabasal spines (*in*, inner ; *ou*, outer) ; *g*, harpago (*cl*, club of dorsal lobe ; *do*, dorsal lobe ; *se*, setae on ventral lobe ; *ve*, ventral lobe). *letifer :* *h*, leaflets ; *i*, harpago ; *j*, parabasal spines ; *k*, tip of inner parabasal spine ; *l*, tip of phallosome with leaflets. *roperi :* *m*, harpago ; *n*, parabasal spines ; *o*, tip of phallosome with leaflets. Scale as for *b*, unless shown otherwise.

de Graaf (1919, p. 44, Table VII) record the variety from the sea coast near Deli, Sumatra, and in Brug's collection there is a series of 37 ♀ of *baezai* labelled "Rantau Pandjang, Swellengrebel, 1917." Rantau Pandjang is not far from Deli, and was almost certainly the site of some of the breeding places recorded under Deli in Table VII.

Specimens seen.—MALAY PENINSULA: (B.M.), 1920, 1 ♀ (*Hacker*); Perak, 1913, 1 ♀ (*Stanton*). (I.M.R.), Province Wellesley, Bukit Toh Panjang, 26.iv.34, 3 ♂, 4 ♀ (*E.P.H.*); Penang, iv.34, 3 ♂, 2 ♀ (*E.P.H.*); Pahang, Kuantan, viii.34, 6 ♀ (*E.P.H.*), 22.iii.49, 3 ♂, 5 ♀ (*J.A.R.*); Selangor, coastal localities between Klang and Kuala Selangor, 1933–1946, numerous specimens; Negri Sembilan, Port Dickson, 10.vii.48, 3 ♀ (*J.A.R.*).

SUMATRA (B.): Banka island, 3 ♀, 1922, 6 ♀ (Block) (these 6 ♀ are very pale, but this may be due to bleaching); west coast, Sibolga, 7 ♀, caught as adults; East coast, Rantau Pandjang, 1917, 37 ♀ (*Swellengrebel*).

BORNEO: (I.M.R.), Brunei, Kuala Belait, vii.45, 2 ♀ (*D. H. Colless*); Sarawak, Lutong, viii.45, 5 ♂, 4 ♀ (*D. H. Colless*).

Anopheles (*A.*) *letifer* Gater *in* Sandosham, 1944.

Type locality: Malay Peninsula.

Type: Lost. Neotype ♀, and plesiotypes, ♂ and ♀ with corresponding larval and pupal skins from Sijangkang, Klang district of Selangor, Malay Peninsula, placed in British Museum.

Synonym: Sp. A. near *umbrosus* Colless, 1948. *umbrosus* of Gater, 1934 and 1935, also of Puri, 1931, Stanton, 1915, and ? in part of Swellengrebel and Rodenwaldt, 1932, and Christophers, 1933.

Adult ♀.

Closely resembles *umbrosus* and *baezai*, but differs as follows:

Head.—Proboscis and palps less shaggy, except at the base of the palps; appearing thinner than in *umbrosus*. Proboscis 2·0–2·4, av. 2·25 mm., ratio fore femur/proboscis = 1·02. Scales on torus and first flagellar segment of antennae as in *umbrosus*.

Thorax.—Pleurae with rather more silvery-grey pruinosity than in *umbrosus*. Setae: Propleural 0–1, av. 0; sternopleural, upper, 3–6, av. 4·1; lower, 2–5, av. 4·0; spiracular, 3–7, av. 5·1; prealar, 7–10, av. 8·2; subalar, 7–10, av. 8·0. No scales near the subalar setae or elsewhere on the pleurae. The absence of propleural setae at once distinguishes this species from *umbrosus* and *baezai*.

Legs.—Coxae without scales, upper mid coxal setae, 3–6, av. 4·4. Fore tarsi without pale bands, except for occasional specimens (3/16) with minute pale flecks at the joints; mid tarsi the same. Hind tarsi (fig. 2*h*) with small pale bands from once to thrice as long as wide, usually about twice; second usually the longest, the fourth very small. These bands, unlike those of *umbrosus*, are always mainly below the joints on the bases of the segments.

Wings (fig. 3*c*).—Length, 3·4–4·4, av. 3·8 mm. Not so densely scaled as *umbrosus* and *baezai*, so that costa and vein 1 form a slightly less pronounced black margin, and other dark marks appear weaker. Pale marks on costa and vein 1 better developed. Subcostal pale spot almost always present on costa (24/25). Vein 1 always with a sector pale spot (25/25), and sometimes (9/25) with a few pale scales (1–7) on the middle dark mark; subcostal pale spot occasionally (2/25) involving vein 1. Basal dark mark on vein 5 seldom (1/15) extending more than half way to the fork. Vein 6 usually (24/26) without any scattered dark scales above the upper dark mark. Three exceptional female specimens (two from Kedah and one from Perak) have pale scales at the extreme base of 5, and a few dark scales at the base of 6 ; in all other respects they seem typical.

Adult ♂.

Terminalia (fig. 5*h*–*l*).—There appears to be no obvious difference from *baezai*.

Larva.

Very similar to that of *baezai*, differs as follows :—Clypeal hairs : *ic* usually simple ; *oc* 4–10 branches, av. 5·5. Ventral sabre piece of antenna tapering to a simple point ; terminal antennal hair with one or two stout hooked branches (fig. 7*f*).[4] Lateral hair on abd. IV, 2–6. The small chitinized plate on the ventral surface of VII, described by Puri, is not confined to this species, but occurs in all the species dealt with here, though stronger in some than in others. In *barbirostris* and *hyrcanus* it is most often absent. Prothoracic hair 4 differs from that of *umbrosus* and *baezai* by having the branches on the stem of the hair short and inconspicuous (fig. 8*b*).

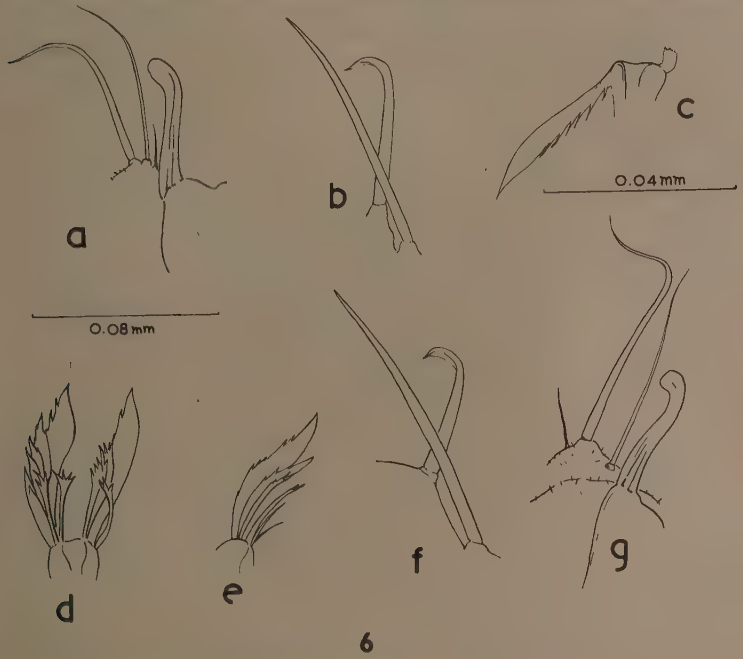

FIG. 6.—Male terminalia. *brevirostris* : *a*, harpago ; *b*, parabasal spines ; *c*, tip of phallosome with one leaflet. *separatus* : *d*, tip of phallosome with leaflets ; *e*, leaflets on one side of another specimen ; *f*, parabasal spines ; *g*, harpago. Scale as for *a*, unless shown otherwise.

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[4] Mr. Colless informs me (*in litt.*) that whilst larvae of *letifer* from the mainland of Borneo have these hooked branches on the terminal antennal hair, those from Labuan Island rarely show it, and have *pc* simple or bifid.

Pupa (figs. 9*d*, 12*e*, 13*j*–*l*).

Resembles that of *brevipalpis* (p. 304) by having similar projecting flanges on the ventrolateral angle of the dorsal plate and on the wing case, and the trumpets meeting in the mid dorsal line. Tragus very complexly folded. Posterior margins of tergites with teeth; lateral spine of V blunt apically, about three times as long as broad. Paddle almost as wide as long, slightly pigmented at the base. For further description see Crawford (1938, *umbrosus*).

For other illustrations of this species see the following: *Adult* ♀, Gater, 1935, p. 177 (fig. 133 of the wing is incorrect, and corresponds more closely to that of *roperi*, as it shows a terminal fringe spot at 2.1), Colless, fig. 10; ♂ *terminalia*, Christophers, fig. 26/2, 3, 5, 8; *larva*, Stanton, 1915, fig. 15, Puri, pl. 27, Gater, 1934, p. 105, Hodgkin, 1945, p. 14, Colless, fig. 10; *pupa*, Crawford, p. 68.

Identification.

The absence of propleural setae, the fore tarsi unbanded, the hind tarsi with the pale bands mostly below the joints and the palps less shaggy are characters distinguishing *letifer* from *umbrosus* and *baezai*. For characters distinguishing it from *roperi* see the key (p. 283). In the larva the small number of branches on *oc* will distinguish *letifer* from most of the other species. The hooked terminal antennal hair will distinguish it from all but *brevipalpis* and *roperi*; from these it is distinguished as in the key.

Distribution.

Malay Peninsula, Sumatra (Banka), Borneo.

Notes.

Gater (1935) recognized that this species, which he then described under the name *umbrosus*, was almost certainly not the same as Theobald's type of *umbrosus*. In a personal communication he tells me that after a further examination of the species in 1941 he redescribed it, naming it *letifer*. The manuscript was sent to England together with the type specimens, but it now appears that it was probably lost at sea by enemy action. Sandosham (1944), assuming that publication had taken place, referred to the species as *letifer* Gater, 1941, and quoted Gater's discovery that the pharynx is distinctive. He says: "*A. letifer* has been recently described by Gater as a distinct species, and differs from *umbrosus* Theobald, 1903, with which it has been confused for many years in Malai, in the absence of propleural setae, and in possessing a group of sclerotized papillae on the posterior hard palate of the pharnyx, between the pigmented area and the region above the ventral papillae." Examination shows that there is a pronounced sclerotized and deeply pigmented area in the position described (fig. 15*a*), though it probably does not bear any papillae like the other palatal papillae, which are small setae with the usual articulated base. This sclerotized and pigmented patch is absent in *umbrosus* Theo., and only moderately developed in *roperi* (fig. 15*b*) and *baezai*. This is important in fixing the identity of *letifer*, for although it is clear that Gater intended the fairly common species described here as *letifer*, both *letifer* and *roperi* have been confused under the name *umbrosus*, and it seems that Gater may have had specimens of *roperi*, for his figure of the wing of *umbrosus* (1935), p. 177, shows

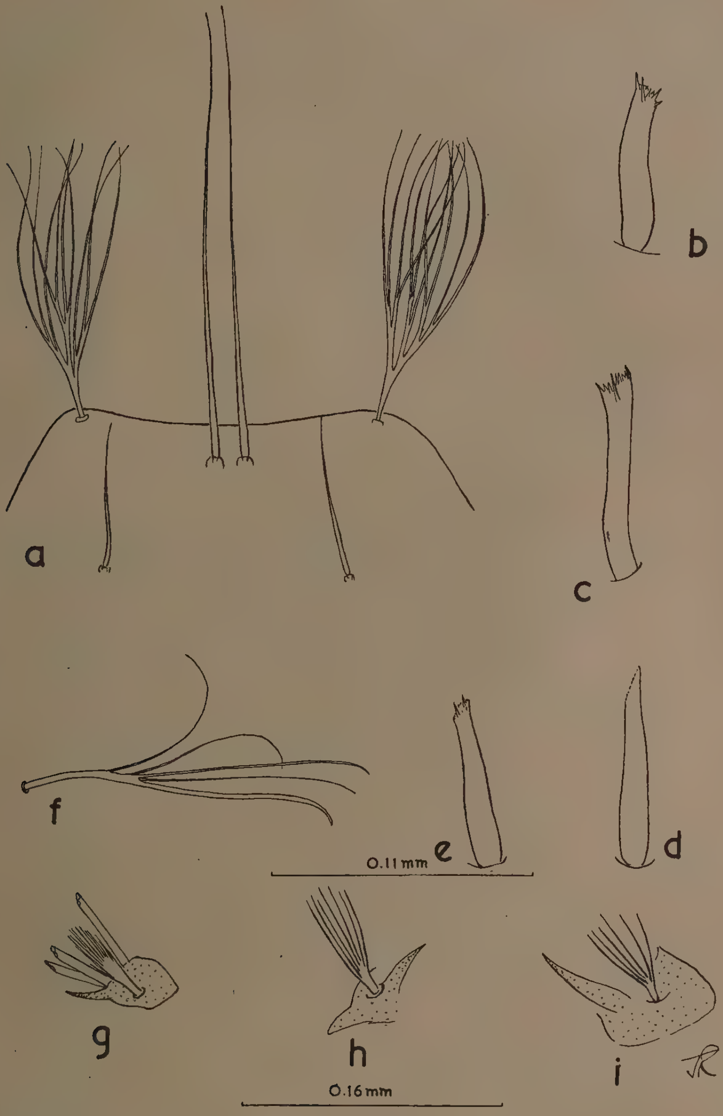

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Fig. 7.—Larval structures. *brevirostris :* *a*, clypeal hairs ; *b*, ventral sabre piece of antenna ; *c*, the same—a different view. *umbrosus :* *d*, ventral sabre piece of antenna ; *g*, dorsal posterior pleural hair of the prothorax (dp1). *baezai :* *e*, ventral sabre piece of antenna. *roperi :* *f*, terminal antennal hair. *letifer :* *h*, dp1. *barbirostris :* *i*, dp1.

an apical fringe spot at 2.1, which is distinctive of *roperi* (Swellengrebel and Rodenwaldt, 1932, pl. vii show the same). Since Gater's types of *letifer* were lost fresh type material has been selected and placed in the British Museum.

Specimens seen.—MALAY PENINSULA (I.M.R.): Kedah, Kuala Ketil, 6.ii.49, 2 ♀ (*J.A.R.*), Kg. Pokok Tai, 20.ix.49, 2 ♀ day biting (*J.A.R.*) (exceptional specimens); Perak, Kota Stia, 7.v.48, 1 ♀ (*J.A.R.*) (exceptional specimen); Province Wellesley, kg. Sunjei Kedak, 17.x.49, 1 ♀ (*J.A.R.*); Pahang, 27.viii.34, 1 ♀ (*E.P.H.*); Selangor, numerous specimens from various localities on the coastal plain, 1933–49.

SUMATRA (B.): Banka, 2 ♀. BORNEO: (B.M.), Sarawak, ? Kuching, 1914, 1 ♀ (*J. C. Moulton*); Brunei (I.M.R.), Kuala Belait, 25.vii.45, 1 ♀ day biting, viii.45, 2 ♀, 18.v.48, 1 ♂, 1 ♀ (*D. H. Colless*).

Anopheles (A.) roperi sp. n.

Type locality: Kuala Kubu Bahru, Selangor, Malay Peninsula.

Type: Holotype ♀ and allotype ♂ with their larval and pupal skins, plus paratypes, placed in Brit. Mus. (Nat. Hist.)

Synonym: A. umbrosus, largest variety of Roper, 1914. Species B near *umbrosus*, Colless, 1948.

Adult ♀.

A very large species which has been confused with *letifer* because of the close resemblance of the larvae and the superficial resemblance of the adults which, like *letifer*, lack propleural setae. Uncommon in collections; differs from *letifer* as follows:

Head.—Palps and proboscis shaggy as in *umbrosus*. Proboscis 2·3–2·8, av. 2·6 mm., slightly longer than fore femur, ratio = 0·97.

Thorax.—Lacks the broad ashy grey band on the mesonotum, which characterizes the three preceding species; instead there is a mottled pattern of light and dark patches occupying the lateral as well as the median area of the mesonotum. Setae: Propleural, 0 (1/20 with 2 and 3 very small setae); sternopleural, upper, 7–17, av. 12·1; lower, 3-7, av. 4·2; spiracular, 6–10, av. 7·4; prealar, 13–16, av. 14·2; subalar, 8–11, av. 9·6 (2/5 with 1–2 associated scales at the anterior end of the row of setae, not antero-ventral as in *baezai*). Note the large number of upper sternopleural setae.

Legs (fig. 2*d*, *i*).—More extensively pale beneath. Coxae and trochanters with scales, usually pale. Fore coxae with scales (14/20), mid coxae (20/20), hind coxae (15/20). Upper mid coxal setae, 6–12, av. 8·5. Fore tarsi with minute apical pale bands or flecks, 1 and 2 best developed, 1 up to as long as wide, sometimes extending slightly on to the lower side of the joint. Mid tarsi with similar minute pale bands (18/20). Hind tarsi with small pale bands about as long as wide, 2 and 3 up to twice as long as wide, and 3 on both sides of the joint, occasionally (2/16) mainly on the lower side; intermediate in this respect between *umbrosus* and *letifer*. Base of hind tibia with a pale band one and a half to three times as long as wide; no such pale band in *umbrosus*, *baezai* or *letifer*, though the femoro-tibial joint may appear pale when open.

Wing (fig. 4*a*).—Length 3·9–4·9, av. 4·5 mm. A more speckled and brightly marked wing than *letifer*, with broader scales about 4 times as long as broad (3·06–4·94, av. 3·8 times), those of *letifer* about 5 times (4·55–5·18, av. 4·9 times). Measurements made on the basal one-third of 2.2. Anterior edge of costa between humeral cross vein and extreme base always with at least a trace of pale scales (50/50), tending to form two marks, one at extreme base and the other by the humeral cross vein. Subcostal pale spot always present on costa, involving tip of subcosta, and usually (23/25) vein 1. Remigium with some pale scales, vein 1 with some scattered pale scales in the basal one-third; sector pale mark always present and involving Sc, middle dark mark (24/25) with a few (1–18) pale scales. Three apical fringe spots always present, at terminations of veins 1, 2.1 and 2.2–3. Vein 5 always with some pale scales at extreme base proximal to upper dark mark ; distal to this mark there is a variable number of scattered dark scales sometimes forming an additional ill-defined dark mark between the upper one and the fork, and often extending beyond the fork on to 5.2. Vein 6 with scattered dark scales (1–27) above the upper dark mark.

Adult ♂.

The pale area on the extreme base of the costa is better developed than in the female. Abdominal segment VIII may bear a few very slender pale scales on the true ventral surface.

Terminalia (fig. 5*m–o*).—Leaflets distinctive, 4 or 5 pairs, long (about half length of phallosome), narrow and curved, not serrate. Phallosome about half as long as coxite. Ventral lobe of harpago with three spines ; club on the dorsal lobe formed of five or more fused spines.

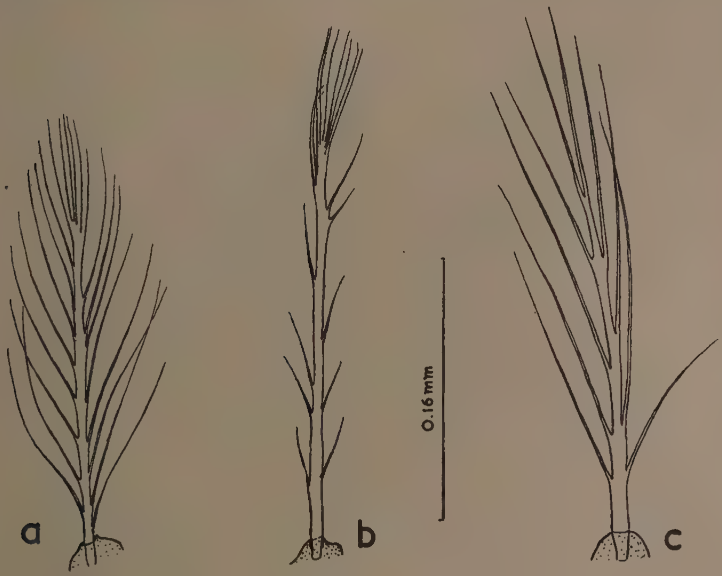

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FIG. 8.—Prothoracic hair 4. (*a*) *umbrosus*, (*b*) *letifer*, (*c*) *barbirostris*.

Larva.

Very closely resembles *letifer* ; has the same hooked terminal antennal hair (fig. 7*f*) and rather large hair 0 on II–VII ; prothoracic hair 4 is also similar. Not all hairs have been systematically examined yet, but apparently differs only by having more branches on the lateral hair of III, and on hair 0.

	roperi.	*letifer.*
Lateral III.	21–26, av. 23·4 (25).	13–20, av. 16·8 (37).
No. 0, III.	5–6, av. 5·3 (10).	3–4, av. 3·5 (10).

Figures in brackets are the numbers of specimens examined.

Pupa (figs. 10*a*, 14*a–c*).

The living pupa was not seen, but skins show a pigmented flange at the ventrolateral angle of the dorsal plate (root of the trumpet) and a very small pigmented boss on the wing case. Tragus of respiratory trumpet rather broad, somewhat spatulate. Posterior margins of tergites with teeth, lateral spine of V about three and a half times as long as broad, obliquely pointed. Paddles rather more than three-quarters as wide as long, not pigmented. Sides of male genital plate parallel, not convergent as in *letifer*.

For other illustrations of this species see Colless, p. 94, fig. 11, the wing.

Identification.

Distinguished from the rest of the *umbrosus* group by the combination of absence of propleural setae, presence of a mottled pattern on the mesonotum, additional fringe spot at 2.1, pale scales on the extreme base of 5, the basal one-third of 1 and the remigium, and often the base of the costa, and a pale band at the base of the hind tibia. Distinguished from *A. montanus* and *albotaeniatus* by the lack of propleural setae and of a white tip to the hind legs, and the presence of the additional fringe spot at 2.1. Larvae: see remarks under *letifer*.

Distribution.

Malay Peninsula, Sumatra and Borneo.

Notes.

It is clear that this species is the large variety of *umbrosus* referred to by Roper (1914), who noted the additional fringe spot at the end of the wing; Colless is of the same opinion. One of Roper's specimens in the British Museum is this species; the rest are *umbrosus*, which (possibly with *letifer* as well) evidently made up the bulk of the specimens seen by him. He thought he could distinguish three forms—a large, medium and small.

Specimens seen.—MALAY PENINSULA (I.M.R.): Selangor, Kuala Kubu Bahru, 4.iv.41, 3 ♂, 3 ♀, 19.v.41, 5 ♂, 5 ♀ (*E.P.H.*), 29.vi.42, 15 ♂, 10 ♀ (*P. D. Rajamoney*), Ampang, 29.iii.40, 3 ♂, 1 ♀ (*E.P.H.*), Bukit Hitam estate, Puchong, 14.v.36, 1 ♀; Negri Sembilan, Gemas, 21 and 26.viii.1918, 4 ♀ (*H. P. Hacker*), 6.iii.46, 12 ♂, 5 ♀, 1.v.47, 1 ♀ (*J.A.R.*), Ladang Geddes estate, Bahau, 15.xii.47, 2 ♂, 3 ♀, 25.iv.48, 19 ♂, 53 ♀ (*J.A.R.*).

SUMATRA (B.): Rantau Pandjang, 1917, 1 ♀ (*Swellengrebel*).

BORNEO: (B.M.) Membakut, Mawao estate, 1914, 1 ♀ (*R. Roper*); (I.M.R.) Kuala Belait, vii.45, 1 ♀ day-biting, Seria, vi.48, 2 ♀ (*D. H. Colless*).

Anopheles (A.) brevirostris sp. n.

Type locality: Bangi, Selangor, Malay Peninsula.

Type: Holotype ♀ and one paratype ♀, with larval and pupal skins from Bangi, and one allotype ♂ without skins from Sijangkang, Selangor, placed in the Brit. Mus.

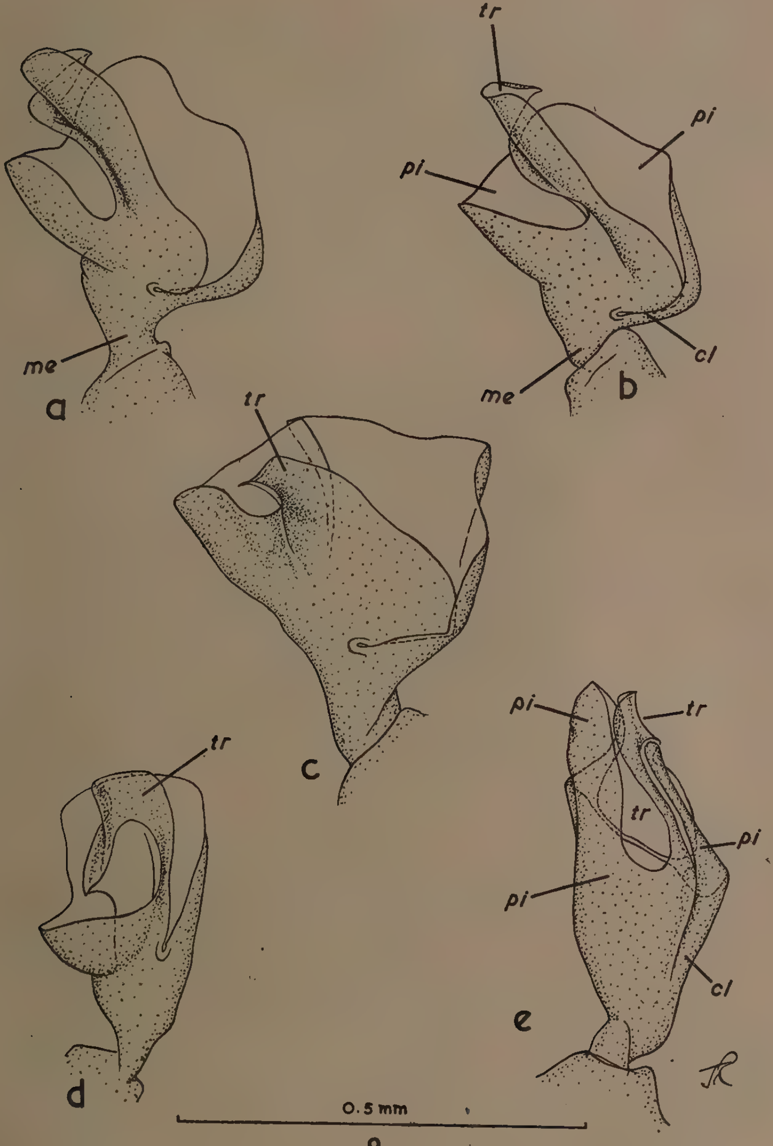

FIG. 9.—Pupae : respiratory trumpets of the left side as if viewed from behind, drawn from mounted skins. (*a*) *umbrosus*, (*b*) *brevirostris*, (*c*) *baezai*, (*d*) *letifer*, (*e*) *brevipalpis*. Symbols : *cl*, meatal cleft ; *me*, meatus ; *pi*, pinna ; *tr*, tragus.

Adult ♀.

A rare small species which has been confused with *umbrosus* (to which it is closely related) because the larvae have similar partially developed palmate hairs. Differs from *umbrosus* as follows :

Head.—Palps and proboscis shaggy as in *umbrosus*, but very short, only about three-quarters as long as the fore femur. Proboscis 1·1-1·4, av. 1·2 mm., ratio fore femur/proboscis = 1·37.

Thorax.—Median area of the mesonotum ashy grey, perhaps more pronounced than in *umbrosus*. Setae : Propleural, 1–1, av. 1 ; sternopleural, upper 0–1, av. 1 ; lower, 3–4, av. 3·4 ; spiracular, 2–3, av. 2·1 ; prealar, 1–4, av. 2·5 ; subalar, 1–2, av. 1·3, no scales.

Legs.—Coxae without scales, upper mid coxal setae 2–3, av. 2·1. Fore tarsi (fig. 2*e*) with broad pale bands extending on both sides of the first and second joints, though principally above the joints ; 3–4 times as long as wide. Mid tarsi with very small apical pale bands or flecks. Hind tarsi with small apical pale bands about as long as wide, third band sometimes extending across the joint.

Wings (fig. 3*d*).—A brighter wing than that of *umbrosus*, the two apical fringe spots paler and usually larger. Length 2·7–3·1, av. 2·9 mm. Sc pale spot present on costa, but not involving vein 1. Vein 1 with small sector pale spot (6/6). Pale mark on 2.2 one-third to three-quarters the length of 2.2. Basal dark mark on 5 sharply defined, extending less than half way to the fork (about one-third). No dark scales on the base of 6 above the upper dark mark. Cross vein 3–4 level with Sc pale spot (6/6).

Adult ♂.

One specimen without larval or pupal skin is evidently this species, as it agrees in all particulars (size, wing markings, chaetotaxy, tarsal banding) with the above description, except that the proboscis is not shorter than the fore femur, but longer ; in this, however, it agrees with the males of the other species. The ratio for femur/proboscis in this specimen is 0·86, in two males of *umbrosus* it was 0·82 and 0·80, and in two of *roperi* it was 0·73 and 0·77. The fore tarsal bands are wider than in the females.

Terminalia (fig. 6*a–c*).—Relative length of phallosome and leaflets much as in *baezai* ; leaflets serrate, number not determined. Ventral lobe of harpago with two spines, longer than the dorsal clubbed process, and a third small spine.

Larva.

Differs from *umbrosus* as follows : Clypeal hairs (fig. 7*a*) : *ic* simple, *oc* 10–13 branches, av. 11·1 ; *pc* simple or with two branches, large, reaching to or beyond the bases of *ic*, much smaller in *umbrosus* not nearly reaching the bases of *ic*. Ventral sabre piece of antenna spinous apically (fig. 7*b*, *c*). Prothoracic hair 4 as in *umbrosus* and *baezai*. Some abdominal palmate hairs present, but none as fully developed as those on IV and V of *umbrosus*, but poorly developed on more segments. Those on I and II with 4–6 narrowly lanceolate leaflets, III with about 10 leaflets, IV and V best developed with about 14 leaflets, slightly pigmented at extreme base, but without a differentiated filament, VI and VII small with about 6 branches, filamentous or slightly flattened. No stigmal club on spiracular apparatus.

Pupa figs. 9*b*, 13*g-i*.

Living pupa not seen. Respiratory trumpet much resembling that of *umbrosus*, but tragal lobe a little differently folded. Teeth on the posterior margins of the tergites weak, lateral spine on V short, bluntly rounded, about twice as long as broad. Paddle about three-quarters as wide as long, with the base strongly pigmented.

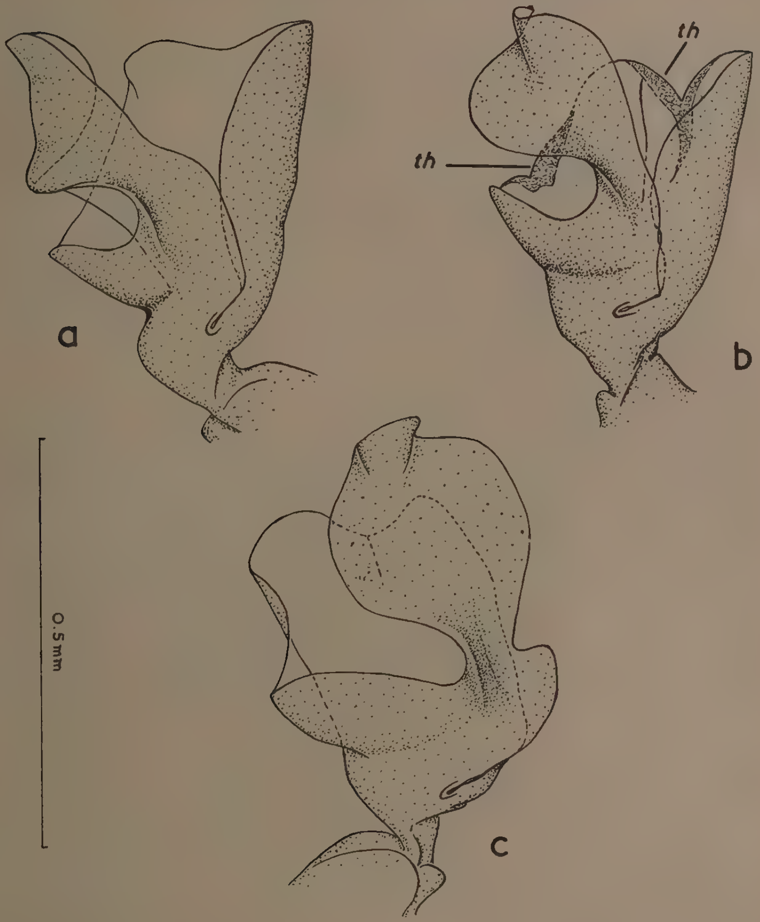

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FIG. 10.—As fig. 9. (*a*) *roperi*, (*b*) *separatus* (*th*, pigmented thickenings on rim of pinna), (*c*) *albotaeniatus*.

Identification.

Distinguished by the short palps and proboscis, only about three-quarters as long as the fore femur, the broad pale bands on the fore tarsi and the small size. Larvae much like those of *umbrosus*, but without stigmal filament, and *pc* longer.

Distribution.

At present known only from two localities in the Malay Peninsula.

Specimens seen.—MALAY PENINSULA (I.M.R.): Selangor, Bangi, 7.iii.34, 3 ♀, 12.iii.34, 2 ♀ (*E.P.H.*), 2.vi.42, 1 ♀ (*P. D. Rajamoney*), Kg. Sijangkang, 14.xii.42, 1 ♂ (*P. D. Rajamoney*).

The five species just described—*umbrosus*, *baezai*, *letifer*, *roperi* and *brevirostris*—are very similar in general appearance as adults, and have all been confused in the past. There follow brief descriptions and notes on the remaining species having larvae without developed palmate hairs. Except for *similissimus*, these species cannot be confused as adults with the preceding ones. For fuller descriptions see Gater (1934, 1935).

Anopheles (*A.*) *brevipalpis* Roper, 1914.

Type locality : Membakut, North Borneo.
Type : In Brit. Mus.

Adult ♀.

A large dark anopheline, easily distinguished by its culicine-like appearance, unicolorous and unornamented with thin palps shorter than the proboscis. On account of these characters and the culicine resting attitude *brevipalpis* has usually been placed in the series *Anopheles*, e.g. Edwards (1932) ; no doubt these characters represent a real affinity with the series, but in the writer's opinion the balance of characters clearly places it in the series *Myzorhynchus* as the following comparison shows. For remarks on the characters of the series *Myzorhynchus*, and of species groups within it, see p. 312.

Affinities of A. brevipalpis.

Affinities with series Anopheles.

Adult : Wings unornamented, with narrow scales. Palps thin. Resting attitude almost culicine, whole insect unicolorous.

Affinities with series Myzorhynchus.

Adult : Front femora considerably swollen towards the base. Male terminalia with well-developed processes on the 9th tergite. Spines on the dorsal lobe of the harpago fused into a club. Outer parabasal spine straight.

Pupa (figs. 9*e*, 12*d*, 13*m*–*o*) : Closely resembles that of *letifer*, with lateral projections on the cephalothorax, trumpets complex, meeting in the mid-dorsal line in the living pupa, and having a large tragus. Abdominal lateral spines short and rounded, tergites with teeth on the posterior margins.

Larva : No developed palmate hairs ; closely resembles the larvae of *letifer* and *roperi*, has the same hooked terminal antennal hair and prothoracic hair 4 is similar. Pleural hair *dpl* divides at the base into about six spine-like branches (fig. 7*g*, *h*, *i*). Abdominal VII with a small median ventral chitinized plate.

Strickland (1915) proposed the genus *Memnemyia* for *brevipalpis*, and Swellengrebel and Rodenwaldt (1932) retain it as a group name, *brevipalpis* being the only member ; but the affinities of this species with the *umbrosus* group are so clear and detailed that there seems no object in placing it in a separate group, despite its somewhat anomalous adult appearance.

The length of the palps in the female is variable ; Strickland (1915, fig. 1) found them only a little shorter than the proboscis ; Roper found them less than three-quarters as long. Examination of a series shows specimens agreeing with both these descriptions.

Adult ♂.

Palps not shorter than the proboscis.

Terminalia.—Somewhat similar to *letifer*, but leaflets fewer, usually four pairs, scimitar-shaped. Ventral lobe of harpago with one long stout spine and usually a second very small one.

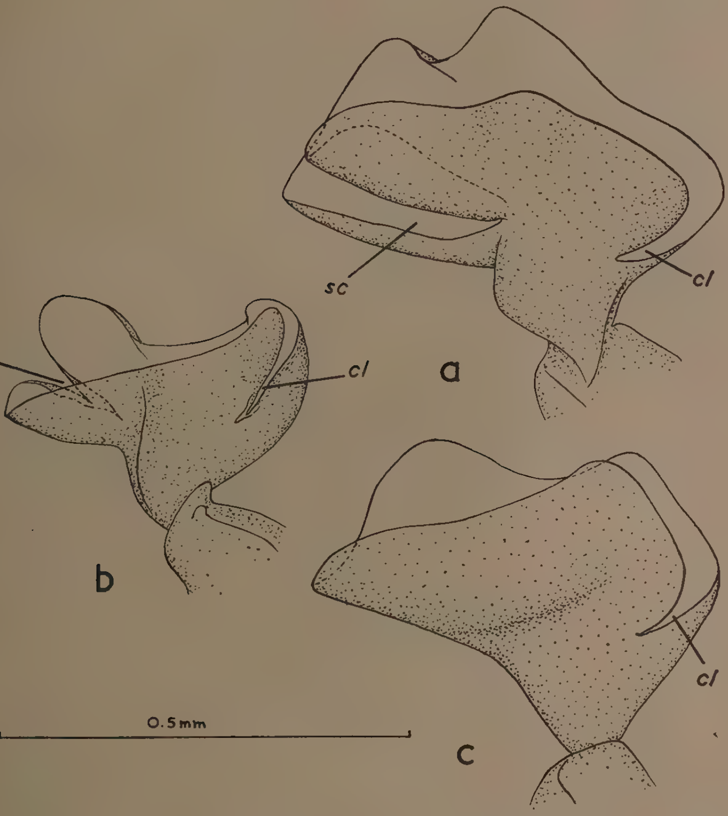

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FIG. 11.—As fig. 9. (*a*) *montanus*, (*b*) *barbirostris*, (*c*) *hyrcanus*. Symbols : *cl*, meatal cleft ; *sc.*, secondary cleft.

Larva.

The mature larva, first described by Stanton and Hacker (1917), is so like that of *letifer* that it is often difficult to distinguish. Clypeal hairs : *pc* large, reaching to or beyond the bases of *ic*, and with an average of four branches ; in *letifer* these hairs are smaller and do not usually reach the bases of *ic*, but this may not be an easy character to see when identifying living larvae as the head is darkly pigmented. As noted by Colless, Bornean specimens seem to average fewer branches on *pc* than do Malayan ones. There are more branches on *oc* than in *letifer*, an average of 10·3 against 5·5, and rather more on the antennal hair. Often the base of the antenna is darkly pigmented; this is not common in *letifer*. The terminal antennal hair is hooked as in *letifer* and *roperi*, and prothoracic hair 4 is similar. The figure of the larva given by Strickland and Choudhury (1927, p. 27) is of a first instar larva and is taken from Strickland's paper of 1915.

Pupa (figs. 9*e*, 12*d*, 13*m*–*o*).

In the living pupa there is a large pigmented flange at the ventrolateral angle of the dorsal plate (root of the trumpet), and posterior to this another on the wing case. The trumpets are directed inwards and more or less touch in the mid-dorsal line. The mouth of the pinna is largely occluded by the somewhat rectangular tragus. In mounted skins the trumpets are also quite characteristic (fig. 9*e*). Posterior margins of tergites with teeth. Lateral spine of V short, rounded, about twice as long as broad. Paddle more than three-quarters as wide as long, heavily pigmented at base, the branched lateral spine of VIII not arising as usual from the apex of the segment, but internal to this point.

For other illustrations of this species see the following: *Adult*, Stanton, 1926, p. 71 (drawing by Terzi), Gater, 1935, p. 150, Colless, p. 78; ♂ *terminalia*, Swellengrebel and Rodenwaldt, p. 103, Colless, p. 78; *larva*, Gater, 1934, p. 75, Colless, p. 78; *egg*, Strickland, 1915.

Identification.

Readily identified by its unicolorous culicine appearance, with thin palps shorter than the proboscis. The larvae usually have the tips of *ic* divided into 2 or 3 branches in a somewhat characteristic manner (Gater, 1934, p. 75), and *pc* are large, reaching to or beyond the bases of *ic*, and with up to 9 branches.

Distribution.

Malay Peninsula, Sumatra and Borneo.

Anopheles (*A.*) *separatus* Leicester, 1908.

Type locality: Kuala Lumpur, Malay Peninsula.
Type: Lost. Cotypes, 2 ♀, 1 ♂, in Brit. Mus.
Synonym: *snijdersi* Swellengrebel, 1921.

Adult ♀.

Bears a superficial resemblance to *A. hyrcanus*, but lacks the tuft of scales on the ventral surface of VII in the female, and the scale tufts on the clypeus of both sexes, present in *hyrcanus*. In addition the wing conforms to the *umbrosus* type, there being no pale scales at the base of 5 or on the remigium and basal one-third of 1, and no fringe spot at 5.2; *hyrcanus* has pale scales at these points and usually a pale fringe spot at 5.2. The pale bands on the palps are somewhat different; the apical segment in *separatus* is all pale, but generally bears two pale bands in *hyrcanus*. The median area of the mesonotum of *separatus* is all grey as in *umbrosus*, though much less pronounced.

Adult ♂.

Best distinguished from *hyrcanus* on the wing characters (see above) and the absence or scarcity of pale scales on the basal half of the palps. True ventral surface of VIII with

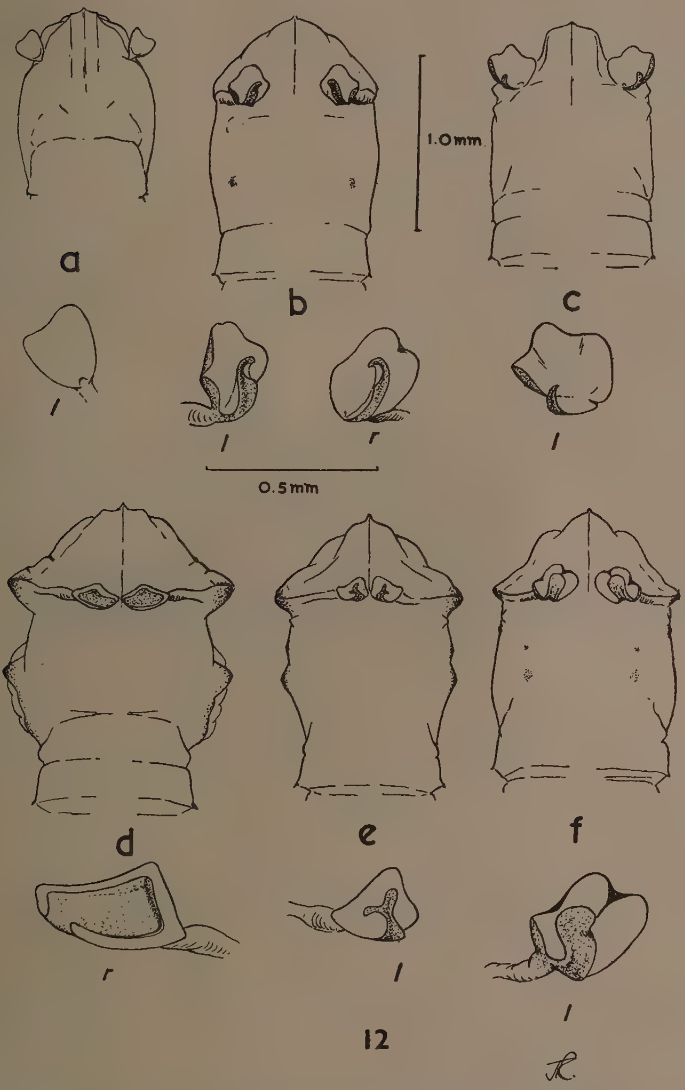

FIG. 12.—Sketches of living pupae, cephalothorax and trumpets seen from above, setae omitted. (*a*) *aitkeni* var. *bengalensis* to show simple trumpets directed outwards, (*b*) *umbrosus*, (*c*) *baezai*, (*d*) *brevipalpis*, (*e*) *letifer*, (*f*) *separatus*. Symbols : *l*, left trumpet ; *r*, right.

pale scales; usually much less numerous in *hyrcanus*. The key characters used by Gater (1935, p. 142) are not satisfactory; it is difficult to see the clypeal scale tufts in the males, and the lower apical fringe spot in *hyrcanus* is very variable.

Terminalia (figs. 6*d*–*g*).—Leaflets of phallosome 4–5 pairs, conspicuous, some broad and serrate, some short narrow and more or less forked apically. Harpago with three lobes.

Larva.

Distinguished from the larvae of *letifer*, *brevipalpis* and *roperi* by the bushy antennal hairs, 25–36 branches against 7–15; the terminal antennal hair is without stout hooked branches, and the undeveloped palmate hairs have more branches, on III–V, 18–25 against 3–12. The posterior clypeal hairs are simple, and are usually branched in the other three species; this character has been much used to differentiate *separatus* from *letifer*, but is very difficult to see in living specimens, which are usually darkly pigmented. Prothoracic hair 4 much as in *letifer*.

Pupa (figs. 10*b*, 12*f*, 14*d*).

With a flange at the root of the trumpet, but no obvious projection on the wing case; trumpets approximated in the mid-dorsal line, though not meeting. Tragus broad, spatulate, edge of pinna with two thickened or pigmented areas. Posterior margins of tergites with small teeth, lateral spine of V short, rounded, about twice as long as broad. Paddle about two-thirds to three-quarters as wide as long, pigmented at the base. For further description see Crawford, p. 63.

For other illustrations of this species see the following: *Adult*, Gater, 1935, p. 175, Hodgkin, 1945, p. 10, Colless, p. 89; ♂ *terminalia*, Swellengrebel and Rodenwaldt, fig. 21*a*, Christophers, p. 163, Colless, p. 89; *larva*, Gater, 1934, p. 102, Hodgkin, p. 14, Colless, p. 89; *pupa*, Crawford, p. 64.

Identification.

In the female the broad pale band at the tip of the palps and the absence of a ventral scale tuft on VII distinguishes this species. The larvae can usually be identified by the bushy antennal hairs.

Distribution.

Malay Peninsula, Sumatra and Borneo. Brug and Bonne-Wepster record it also from Moluccas (Buru), which is somewhat surprising.

Notes.

Leicester described only the adult female. James and Stanton (1912) state that the type, together with other types of Leicester's, was lost in transit to Theobald at the British Museum. They studied specimens remaining in Leicester's collection at this Institute (no longer extant), and the specimens of this and other species now at the British Museum were presumably selected by them, and are best regarded as cotypes. One of Leicester's cotype females of *separatus* is labelled "*Myzomyia dubitans*" a MS. name "Own bungalow, Kuala Lumpur, 17.xi.03"; this is noted by Christophers (1924). There has been much confusion over the identity of *separatus* and the next species, *hunteri*.

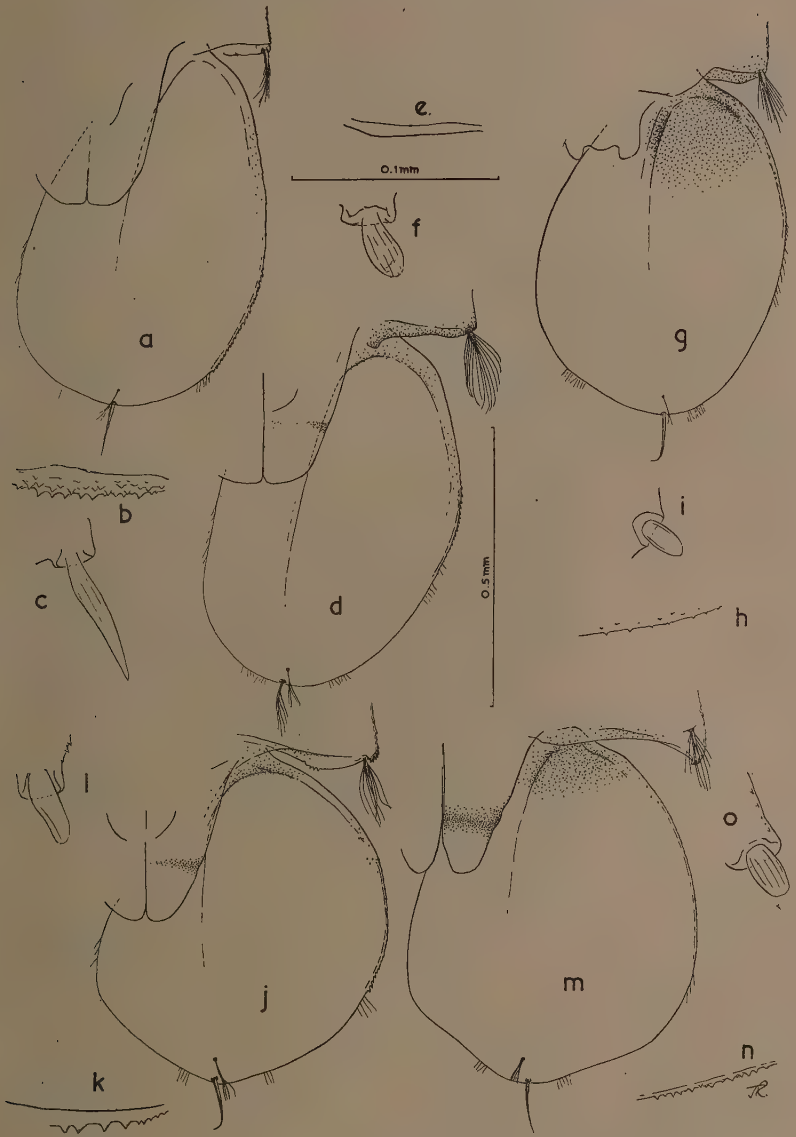

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FIG. 13.—Pupae ; paddles ; also posterior border of tergites, and lateral spines, of segment V. (*a, b, c*) *umbrosus*, (*d, e, f*) *baezai*, (*g, h, i*) *brevirostris*, (*j, k, l*) *letifer*, (*m, n, o*) *brevipalpis*. Drawn from males (except *brevirostris*) to show also the shape of the male genital pouch.

Anopheles (*A.*) *hunteri* Strickland, 1916*a*.

Type locality : Malay Peninsula.
Type : None.

No specimens have been seen. Apparently very similar to *separatus*, but the male lacks leaflets on the phallosome, whilst the larva probably has considerably fewer branches on the antennal hair, and somewhat fewer on the palmate hairs.

From examination of the literature dealing with this species and *separatus*, it seems that no one has compared specimens of the two species, but only rather inadequate descriptions. Some of the figures (Strickland, 1931) for the number of branches on certain of the larval hairs of *hunteri* are little more than guesses based on earlier statements that these hairs were like those of "*umbrosus*"[5] (? *letifer*). The best description of *hunteri* is probably Essed's (1928). He states that all males examined lacked leaflets on the phallosome, and he describes the larva from an examination of eight specimens. He compared his larvae with "*umbrosus*" (? *letifer*), and found them very similar except that the posterior clypeal hairs were simple in *hunteri* and branched in "*umbrosus*"; the antennal hairs were similar to "*umbrosus*." Comparing Essed's description of *hunteri* larvae with larvae of *separatus* (see Appendix, Table III), there appear to be only two differences which can probably be relied on: *hunteri* has fewer branches on the antennal hair (probably under 20) and on the palmate hairs (av. 16 against 18–25). Essed's photographs of the wings of three of his specimens do not reveal any differences from what can be found on examining a series of *separatus*, although specimens with a narrow Sc pale spot, as in Essed's fig. 7, are not common. The lack of leaflets on the phallosome in the male of *hunteri* (an exceptional character in this group of *Anopheles*) noted by both Strickland (1916*a*, fig. 5) and Essed, seems to be the only reliable difference known at present between the adults of the two species; if it were not for this character *hunteri* would probably be synonymized with *separatus*, as it was before Essed's paper appeared. Since *separatus* is fairly common in its own habitat, whilst *hunteri* appears to be rare, it seems likely that Strickland had both species, as he says that he obtained "a large amount of material," and records *hunteri* from a number of localities. Gater (1933*a*) reviews the literature dealing with the two species.

For illustrations of *hunteri* see Strickland, 1916, and Essed, 1928.

Distribution.

Malay Peninsula, Bintan Is. (Riouw), South Natuna Islands.

Anopheles (*A.*) *similissimus* Strickland and Choudhury, 1927.

Type locality : Malay Peninsula.
Type : None.
Synonym : similis Strickland, 1917.

Except possibly for Keukenschryver (1921), no one but Strickland seems to have seen this species: he says (1917): "I have long been cognizant of an anopheline larva of which the salient character is that it possesses clypeal hairs like the common species *sinensis* (= *hyrcanus*), while it is quite devoid of the palmate hairs, which are so marked in that species." The original description, which is not illustrated, is as follows :

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[5] See footnote, p. 295.

> "*Larva.*—Clypeal hairs and other cephalic hairs as in *sinensis.* Anterior thoracic hairs as in *sinensis.* Palmate hairs absent, but represented by a series of filamentous cockades as in *umbrosus.* *Imago.*—The single female specimen which I have is indistinguishable from *umbrosus.*"

The *umbrosus* referred to was probably *letifer.*

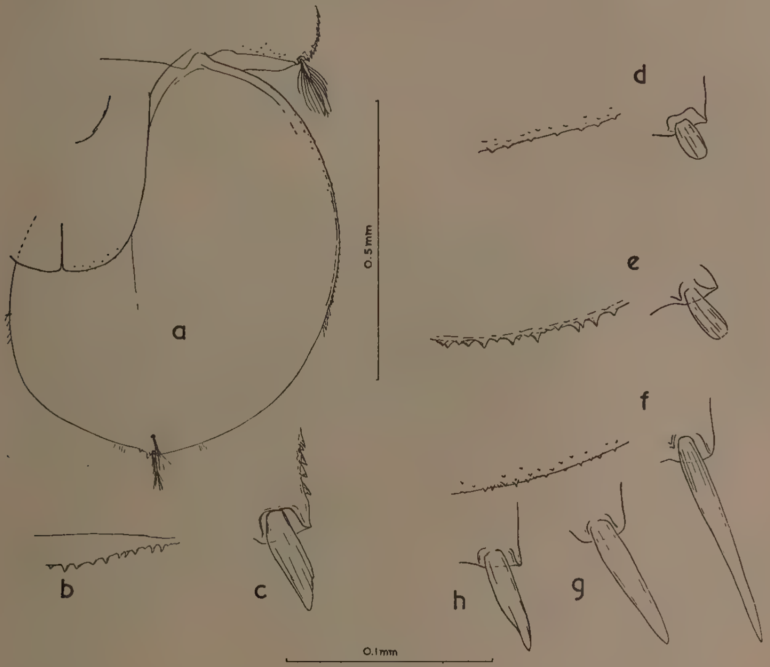

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Fig. 14.—As fig. 13. (*a, b, c*) *roperi,* (*d*) *separatus,* (*e*) *albotaeniatus,* (*f*) *montanus,* (*g*) *hyrcanus,* (*h*) *barbirostris.*

Although this description is woefully brief when taken in conjunction with the later one (Strickland and Choudhury, 1927), it seems to indicate a species quite distinct from any of the others described here, since it has bushy outer clypeal hairs as in *hyrcanus,* but no palmate hairs. There are some references to the species in an unpublished report of Strickland's in this Institute. He says (vol. ii, p. 477) : " *similis.*—This species has only been taken by me and recognized in four places : Sungei Batang Kuala Pilah, Negri Sembilan ; Kuala Pahi estate, Kelantan ; Sungei Batang Johore Bahru, Johore ; Behrang, Perak. It therefore ranges from the coast (not on alluvium) to the hinterland." Three of these localities are well inland, so that *similissimus* cannot be the same as the *umbrosus* larval variation of Swellengrebel (= *baezai*) as suggested by Edwards (1932), since this form is found only in brackish water on the coast.

Strickland's remark "(not on alluvium)" possibly means not on areas of flat coastal plain. It may be that this species should be looked for among low hills, such as seem to form the principal habitat of *roperi* (see Part II, p. 321), and perhaps also of *brevirostris*, and the unnamed larval form described below.

According to Swellengrebel and Rodenwaldt *similissimus* is mentioned by Keukenschryver (1921) as occurring at Kisaran, east Sumatra; the original reference has not been seen.

In addition to the foregoing species, the larva of one other form which appears to be distinct has been encountered, and there may well be other rare forms not yet discovered. It is not surprising that a group which is characteristic of the Malaysian rain forest region should contain a considerable number of species, some of them rare or local.

Larval form from Kelantan.—Similar to *letifer*, but with 7–15 branches on *oc*, av. 10·6, and the saddle hair with 2–3 branches (12/14). The latter is an unusual character not found in any of the other members of the *umbrosus* group. Only one poor specimen was bred out, and a cursory examination at the time did not reveal any differences from *letifer*; the specimens were subsequently lost owing to the war.

Kuala Krai, Kelantan, October, 1941 (*J.A.R.*). Fourteen larvae from the jungle shaded edges of a deep open swamp which was almost a lake.

The following list summarizes the species recognized here as belonging to the *umbrosus group*:

- *A. umbrosus* Theobald.
- *A. baezai* Gater.
- *A. letifer* Gater.
- *A roperi* sp. n.
- *A. brevirostris* sp. n.
- *A. brevipalpis* Roper.
- *A. separatus* Leicester.
- *A. hunteri* Strickland.
- *A. similissimus* Strickland and Choudhury.

4. Classification.

Series *Myzorhynchus*.

Christophers (1933, pp. 100–102 and 144) mentions various characters that appear to be distinctive of the series *Myzorhynchus*. The present study, embracing a larger number of Oriental species than was available to him, in the main confirms his views. Besides seven species in the *umbrosus* group, *A. montanus*, *albotaeniatus*, *hyrcanus* and *barbirostris* have been examined, and it is assumed from the descriptions and a limited examination of specimens that the other species related to *barbirostris* (e.g. *bancrofti*, etc.) also show the same group characters.

The series *Myzorhynchus*, at least so far as Oriental species are concerned, seems to be characterized as follows:

Adult.—Front femora markedly swollen towards the base. Male terminalia with the spines on the dorsal lobe of the harpago fused into a club. In addition the outer parabasal spine is more or less straight, the 9th tergite bears well-developed processes, and the phallosome has leaflets (except *hunteri*); the palps and proboscis of the female are shaggy (except *brevipalpis* and *letifer*), and the wings bear at least a few pale spots and areas of mixed light and dark scaling (except *brevipalpis*). Resting attitude usually markedly anopheline, often almost at right angles to a vertical surface (except *brevipalpis*).

Larva.—The dorsal posterior pleural hair on the prothorax (*dpl*) is branched from near the base into 3–10 or more branches, usually stiff and spine-like (fig. 7*g*, *h*, *i*).

Pupa.—Respiratory trumpet complex in shape; either with a well developed tragus, or boat-shaped and bivalved.

So far as can be determined from the descriptions (Evans, 1938), the African species belonging to the series agree well with this diagnosis.

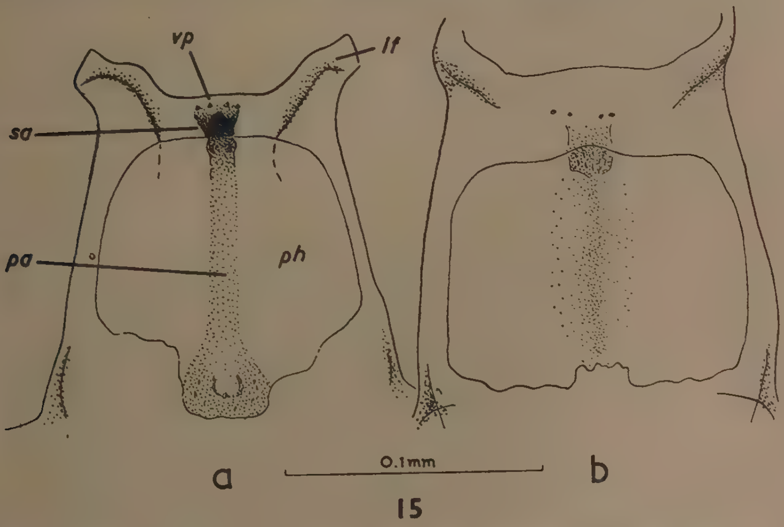

Fig. 15.—Part of pharynx. (*a*) *letifer*, (*b*) *roperi*. Symbols: *lf*, lateral flange; *ph*, posterior hard palate; *pa*, pigmented area of posterior hard palate; *sa*, sclerotized area (Sandosham's sclerotized papillae); *vp*, ventral papillae.

Species Groups.

The Oriental species in the series *Myzorhynchus* fall fairly naturally into two main groups, with a third small group intermediate. The position of one or two of the species depends on whether more importance is given to adult characters or to larval and pupal. In the following key, which serves to display the group characters, the emphasis is on adult characters.

1. Costa from base to Sc pale spot entirely dark; basal one-third of 1 and extreme base of 5 entirely dark. Median area of mesonotum a uniform ashy grey; lateral areas dark. Larvae without developed palmate hairs, or with only a few; hair 4 on prothorax with a concentration of short branches at the tip; a small ventral pigmented plate on VII. Pupal trumpet with a well-developed tragus; posterior borders of tergites with teeth[6] . . . . *umbrosus* group (*umbrosus*, *brevirostris*, *baezai*, *letifer*, *brevipalpis*, *separatus*)

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[6] The pupa of *baezai* lacks teeth on the posterior borders of the tergites.

–. Costa, between base and Sc pale spot, generally with a few pale scales at some point; basal one-third of 1 and extreme base of 5 with pale scales. Median and lateral areas of mesonotum with a mottled or striped pattern. Larvae with fully developed palmate hairs; hair 4 on prothorax not so[7] . . . . 2.

2. Female without ventral scale tuft on VII. No fringe spot at 5.2; pale scales on costa confined to extreme base proximal to humeral cross vein.[8] Larvae with *oc* not bushy, less than 30 branches; a small ventral pigmented plate present on VII. Pupae with teeth on the posterior borders of the tergites, trumpets with a tragus[9] (*roperi*, *albotaeniatus*, *montanus*) *albotaeniatus* group.

–. Female with ventral scale tuft on VII. Usually with a fringe spot at 5.2, and some pale scales on costa between humeral cross vein and Sc pale spot.[10] Larvae with bushy *oc*, more than 30 branches,[11] seldom with a pigmented ventral plate on VII. Pupae without teeth on the posterior borders of the tergites; trumpets boat-shaped and bivalved *hyrcanus* group.
(*hyrcanus*, *barbirostris* and allies)

The African species, with the possible exception of *obscurus*, would fall into the *hyrcanus* group; *obscurus*, with less than 30 branches on *oc*, and the beginnings of a tragus on the pupal trumpet (Evans' dorsal process, fig. 24), tends a little towards the intermediate group. Van Someren (1947) puts *obscurus* in a different group from the others.

For practical purposes it seems best to recognize only two main groups, the *umbrosus* group in which the larvae are without, or with very few developed palmate hairs, and the *hyrcanus* group in which the larvae have a full complement (at least five pairs) of well developed and pigmented palmate hairs. The intermediate *albotaeniatus* group then breaks up, *roperi* joining the *umbrosus* group, and *albotaeniatus* and *montanus* the *hyrcanus* group.

The *umbrosus* group, with a few exceptions, is then well characterized by the ashy top of the thorax, lack of any pale scales towards the base of the wing (except on 6), larva without developed palmate hairs, and prothoracic hair 4 with a concentration of short branches towards the tip. The pupa has a tragus on the respiratory trumpet, and teeth on the posterior borders of the tergites. Within the group, *umbrosus*, *brevirostris* and *baezai* are closely related. On larval and pupal characters *brevipalpis*, *letifer* and *roperi* form a second closely knit group, though as adults they show little relationship, except that *letifer* and *roperi* both lack propleural setae. The adult of *brevipalpis* lacks the ashy top of the thorax, and because of its complete lack of ornamentation, thin palps and culicine resting attitude, the species has hitherto been placed in the series *Anopheles* (see p. 304). *A. letifer* has all the *umbrosus* group characters, but *roperi*, as an adult, is clearly related to *albotaeniatus* and *montanus*, and closely resembles the latter, especially in the pattern of the wing and the top of the thorax. It looks as if the evolution of larval and adult characters in some of these species has proceeded independently along somewhat divergent lines. The extra apical fringe spot at 2.1 is peculiar to *roperi*, whilst *albotaeniatus* and *montanus* have propleural setae and the tips of the hind legs are all white. *A. separatus* stands rather alone; it has all the *umbrosus* group characters as given at the beginning of this paragraph, and although the adult bears a superficial resemblance to *hyrcanus*, it seems unlikely that this indicates more than a remote affinity. The presence in the pupa of a projecting flange below the root of the trumpet, the shape of the trumpet and its tragus, and of prothoracic hair 4 of the larva, indicate affinity with *roperi*, and through this species with *brevipalpis* and *letifer* on the one hand, and *montanus* and *albaoteniatus* on the other.

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[7] Except larvae of *roperi*.

[8] *albotaeniatus* rarely has any pale scales on the base of the costa.

[9] Trumpet of *montanus* without tragus.

[10] Some forms of *hyrcanus* often lack any pale scales on the basal half of the costa and/or a fringe spot at 5·2.

[11] Larvae of *barbumbrosus* have fewer than 30 branches on *oc*.

The *hyrcanus* group cannot be discussed in detail here. The pupae of *albotaeniatus* and *montanus* have teeth on the posterior borders of the tergites, but while *albotaeniatus* has a trumpet very like that of *separatus* and *roperi*, and the lateral spines are short and bluntly rounded, the trumpet of *montanus* belongs to the boat-shaped bivalvate type displayed by *hyrcanus* and *barbirostris*, and as in those species, the lateral spines are long and taper to a point (figs. 10*c*, 11*a–c*, 14*e–h*).

5. DISTRIBUTION.

The *umbrosus* group appears to be largely confined to the Malaysian part of the Oriental region, i.e. the Malay Peninsula, Sumatra, Borneo and Java (see Zeuner, 1943, and Mayr, 1944), and is probably best developed in the first three with their moist uniform climate supporting evergreen tropical rain forests. Outside the Malaysian subregion "*umbrosus*"[12] is recorded as a rarity from two or three localities in Assam, and from the Andaman islands (Christophers, 1933); no specimens have been available, so that the species is undetermined. *A. baezai* has a limited distribution in the Philippines (southward from Camarines Norte to Mindanao and Palawan, Russell and Baisas, 1936), and has been recorded once from south Indo-China (Cap-Saint Jacques) by Farinaud (1938). The single earlier record of "*umbrosus*" from Indo-China (Phurieng) by Morin may have been *baezai*. Swellengrebel and Rodenwaldt, and Brug and Bonne-Wepster record "*umbrosus*" from two localities in Celebes and from Buru in the Moluccas eastward of Weber's line. These records may perhaps refer to *baezai* also, for the late W. G. Venhuis informed me verbally that *baezai* occurs in Celebes, and Brug and Bonne-Wepster report it from here. As *baezai* is a littoral species breeding in or near the mangrove zone which is well known to be very uniform and widespread, it is perhaps not surprising to find it the widest ranging member of the group.

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[12] The use of inverted commas has been found convenient to indicate that the exact species is not known; it seems easier and less technical to write "*umbrosus*" rather than *umbrosus sensu lato*, or *umbrosus sl.* Inverted commas are not used when writing *umbrosus* group, because the reference is to a definite species, *umbrosus* Theobald, the type of the group. The convention might be useful to malariologists in other difficult species groups, such as *A. maculipennis* (see Bates, 1940, and Mayr, 1942), or *punctulatus* (see Mackerras, 1947). The name "*maculipennis*" would then indicate the *maculipennis* group (excepting readily recognizable forms, such as *sacharovi*), or unidentified members of the group, whilst the name *A. maculipennis* would revert to its proper status, meaning *maculipennis* typicus, or, as Bates suggests writing it, *maculipennis* ss. Hodgkin, in Part II of this paper, proposes an alternative convention to serve the same purpose; this is to use plain type instead of italics.

6. SUMMARY.

The *Anopheles* (*Anopheles*) *umbrosus* group is here defined as those species in the series *Myzorhynchus*, the larvae of which lack developed palmate hairs on the abdomen, or have only a few weak ones. It is a natural group of at least nine species, two of which are here described as new. Some of the species are rare, and there are probably others still to be discovered. The group appears to be largely confined to the Malaysian part of the Oriental region (Malay Peninsula, Sumatra, Borneo and Java), where it forms an important and characteristic part of the anopheline fauna. Only *baezai*, which is a coastal species breeding in brackish water, ranges widely outside this area ; it occurs sparingly in French Indo-China, the Philippines and Celebes.

In general the species closely resemble one another, both as adults and larvae, but close examination shows no lack of good specific characters. Examination of the type of *umbrosus* Theobald has shown that *novumbrosus* Strickland is a synonym, while the species that has generally been called *umbrosus* in Malaya is now *letifer* Gater. It has been found that the shape of the pupal respiratory trumpet, in addition to being somewhat characteristic of the group, is very distinctive of each species. The pinna of the trumpet has a well-marked secondary lobe, which varies in shape from species to species, and for which the name tragus is suggested. It is considered that important structural characters in the adult, larva and pupa, show that *A. brevipalpis* belongs with the *umbrosus* group in the series *Myzorhynchus*, rather than in the series *Anopheles*. The characters of the series *Myzorhynchus*, and of groups within it, are discussed.

APPENDIX.

TABLE I.—*Adult Females : Size of Parts (measurements in millimetres).*

	Measurements.				Ratios.			
Species.	Wing length. WL	Wing width. WW	Proboscis. P	Fore femur. F	$\frac{WL}{WW}$	$\frac{WL}{P}$	$\frac{WL}{F}$	$\frac{F}{P}$
baezai	3·7–	0·75–	2·1–	2·15–	4·77	1·76	1·74	1·01
	4·35	0·9	2·45	2·5				
	3·99	**0·84**	**2·26**	**2·30**				
brevirostris	2·72–	0·5–	1·1–	1·5–	5·14	2·34	1·70	1·37
	3·1	0·6	1·37	1·85				
	2·87	**0·56**	**1·23**	**1·68**				
letifer	3·4–	0·7–	2·05–	2·0–	4·87	1·70	1·66	1·02
	4·4	0·95	2·45	2·75				
	3·82	**0·78**	**2·25**	**2·29**				
roperi	3·9–	0·82–	2·27–	2·0–	4·68	1·69	1·75	0·97
	4·9	1·05	2·85	2·9				
	4·46	**0·95**	**2·64**	**2·56**				
umbrosus	3·4–	0·75–	1·9–	1·95–	4·49	1·80	1·68	1·07
	4·1	0·95	2·25	2·45				
	3·81	**0·85**	**2·12**	**2·27**				

Wing measurements are exclusive of the fringe. Proboscis measured from the ventra bristles at the base to the apex of the labella. Figures in bold type are averages based in each case on ten samples (except *brevirostris*, six only).

TABLE II.—*Thoracic Chaetotaxy of Adult Females.*

Species.	Pro-pleural.	Upper sterno-pleural.	Lower sterno-pleural.	Spiracular.	Pre-alar.	Sub-alar.	Upper mid-coxal.
baezai	1–3	3–6	3–6	3–5	9–12	9–19	1–5
	2·6 (21)	**4·6** (14)	**3·9** (14)	**3·7** (10)	**10·8** (5)	**13·5** (21)	**2·9** (14)
brevirostris	1	0–1	3–4	2–3	1–4	1–2	2–3
	1 (8)	**1** (8)	**3·4** (7)	**2·1** (8)	**2·1** (7)	**1·3** (8)	**2·1** (6)
letifer	0–1	3–6	2–5	3–7	7–10	7–10	3–6
	0 (20)	**4·1** (20)	**4·0** (10)	**5·1** (10)	**8·2** (5)	**8·0** (10)	**4·4** (10)
roperi	0–3	7–17	3–7	6–10	13–16	8–11	6–12
	0 (21)	**12·1** (22)	**4·2** (11)	**7·4** (10)	**14·2** (5)	**9·6** (5)	**8·5** (19)
umbrosus	2–6	2–4	3–6	4–7	7–11	1–6	3–7
	4·1 (24)	**2·5** (10)	**4·8** (10)	**5·3** (10)	**9·0** (5)	**3·5** (25)	**4·3** (10)

Figures in bold type are averages ; those in brackets are the number of specimens examined.

TABLE III.—*Larval Chaetotaxy.*

Species.	Head. ic.	oc.	pc.	Sutural.	Trans-sutural.	Antennal.
(1) *baezai*	Tips finely branched	*11–17* 11–25 **15·1** (25)	*1–2*	*3–6*	*2–5*	*13–21*
(2) *brevipalpis*	*2–4* distally. s–4 **2·2** (26)	*6–11* 7–13 **10·3** (25)	*4–7* s–9 **4** (29)	*3–5* s–6 **3·5** (15)	*2–7* 4–8 **5·9** (13)	*10–15* 14–21 **16·2** (10)
(3) *brevirostris*	s (4)	10–13 **11·1** (8)	1–2 (8)	2–4 **2·7** (7)	2–6 **4·3** (7)	12–20 **16·3** (6)
(4) *hunteri*[1]	*s*	*8–10*	*s*	.	.	*like umbrosus (? =letifer)*
(5) *letifer*	*s occasionally branched at tip*	*4–10* 4–7 **5·5** (25)	*2–4*	*s–4*	*2–5*	*7–13*
(6) *roperi*	s (10)	4–7 **5·6** (25)	2–4 **3** (15)	2–4 **3·1** (10)	2–5 **3·6** (10)	9–13 **11·3** (10)
(7) *separatus*	*s*	*10–17* 8–17 **13** (25)	*s*	*2–4*	*5–6*	*25–36*
(8) *umbrosus*	*2–5 distally*	*10–22* 11–20 **14** (25)	*s–7*	*3–7*	*5–9*	*15–25*

	Thorax. Inner shoulder hair.	Middle shoulder hair.	Meso-thoracic I.	Abdomen. Palmate III.	Palmate IV.	Palmate V.	Lateral III.	Lateral IV.	O III.
(1)	*2–5*	*5–10*	*14–21*	*10–16*	*10–16*	*10–16*	29–39 **32·4** (10)	*7–10*	.
(2)	*2–3*	*5–8*	*6–12*	*3–4*	*4–9*	*4–8*	17–24 **19·9** (11)	*3–4*	.
(3)	2–4 **3** (8)	5–8 **6·4** (8)	15–17 **16·2** (5)	approx. 10[2]	approx. 14[2]	approx. 14[2]	26–30 **28** (8)	1–3 **2·2** (8)	.
(4)	*±5*	*±11*	.	*±16*	*±16*	*±16*	.	.	.
(5)	*3–4*	*5–9*	approx. *12*	*5–12*	*5–12*	*5–12*	13–20 **16·8** (37)	*2–6, usually 2–4*	3–4 **3·5** (10)
(6)	2–4 **3·4** (11)	5–7 **6·1** (10)	9–14 **11·7** (10)	5–7 **6·1** (9)	5–8 **6** (9)	6–8 **6·8** (10)	21–26 **23·4** (25)	2–4 **3** (10)	5–6 **5·3** (10)
(7)	*4–5*	*9–14*	approx. *12*	*18–25*	*18–25*	*18–25*	17–22 **18·3** (10)	*3–4*	.
(8)	*2–3*	*7–9*	.	*9–10*	*12–22*[2]	*12–22*[2]	23–30 **26·3** (10)	2–3 **2·6** (10)	.

Figures in italics are from existing publications, nearly all from Gater (1934), a few from Hodgkin (1945). Other figures are original; those in bold type are averages, those in brackets are the numbers of hairs examined; s = simple.

[1] From Essed (1928), based on 8 specimens.

[2] Branches flattened into leaflets forming true palmate hairs.

PART II : BIOLOGY AND TRANSMISSION OF MALARIA.

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1. INTRODUCTION.

In the foregoing section Mr. Reid has discussed the systematics of the *Anopheles umbrosus* group of mosquitoes. In view of the fact that some of the species he has defined anew are important vectors of malaria, it is desirable to sort out the available information with regard to the biology of the group, in so far as this can now be done. *A. baezai* was not recognized as a distinct species until 1933, and although Strickland erected the species *novumbrosus* in 1916, the adults continued to be confused with those of *letifer* until 1936. The three commonest species to which the name umbrosus has been applied (*baezai*, *letifer*, *umbrosus*) show such definite preferences in regard to the selection of breeding places that it is often possible to say with confidence to which of the three the designation umbrosus refers in old reports. Unfortunately, some valuable records cannot be used because the breeding places of two species occurred in close proximity. It is also possible that small numbers of the rarer species have been confused with the common forms.

In what follows the expression *umbrosus* group has been used in the sense defined by Reid for all those *Anopheles* of the series *Myzorhynchus*, the larvae of which lack developed palmate hairs on the abdomen, or have only a few weak ones. The name umbrosus, printed in ordinary type, is used where the identity of the species is in doubt.

2. BREEDING PLACES IN MALAYA.

The breeding places of the *umbrosus* group may be described in general terms as : stagnant or slowly moving water, usually on the acid side of neutrality, seldom exposed to the full sun and often in the jungle or under other heavy shade. The related *albotaeniatus* and *montanus* also breed principally in jungle ; neither species is common.

Anopheles baezai is restricted to the narrow coastal belt where there is brackish water, and it favours those drains and pools which contain some decaying vegetation. These places are often shaded by nipah palms or other plants, but gross shade is by no means invariable. *A. baezai* breeds alongside *A. sundaicus*, although it is neither so widespread nor so abundant as that species. Both tolerate a wide range of salinities, from fresh water to water that is as salt as the sea, but they appear to prefer to breed in places the water of which is renewed at intervals from tidal sources, even though the salinity may not be very high (Hodgkin, 1940). On the Selangor coast the erection of a bund excluded salt water from two breeding places of *sundaicus*, and after a while this species disappeared, despite the fact that the water was still sufficiently brackish ; it was replaced by *hyrcanus*, *barbirostris*, *separatus* and *vagus*. *A. baezai* also disappears with the exclusion of salt water, to be replaced by other species. *A. baezai* appeared to prefer slightly more acid water than *sundaicus* (average pH 6·3 and 6·8 respectively).

Anopheles separatus has a fairly wide distribution, but it is seldom abundant.

It extends from the inner fringe of the brackish water zone inland to the foothills at a few hundred feet above sea level. It is probably commonest on the coastal plain, where it is found breeding characteristically in pools that are under light shade from secondary growth or rubber. It does not appear to breed in virgin jungle. On the Selangor coast it was occasionally found in water containing up to 15 per cent. of sea water. It is generally found in the more acid waters (average pH 5·8), where it is often associated with *A. letifer* (see Hodgkin, 1935).

Anopheles letifer is abundant on the flat coastal plain, where the larvae are found in the many pools and stagnant agricultural drains of the Malay settlements and the plantations. It has a preference for the dark brown water of peaty land that was formerly covered with jungle swamp, but it is found in many places along the coast where there is vegetation in or overhanging the water. This is generally interpreted as a preference for shady positions, but it should not be allowed to obscure the fact that larvae are found in places that have not a vestige of vegetation, or only a little grass, *Chara*, or other water plants. Barrowman (1936) believes that even in these apparently exposed places the larvae require at least the shade of grass blades. The water in such places is generally cool, and temperature may well prove to be a more important limiting factor than shade: *A. letifer* is intolerant of salt water; in a survey of the Selangor coast between Klang and Kuala Selangor it was never found where there was contamination with more than 3 per cent. of sea water, despite its presence in fresh-water pools only a few yards away (Hodgkin, 1940). In this survey the breeding waters of *letifer* were found to have an average pH of 5·8, but the dark peaty water it favours is more acid than this. *A. letifer* does not breed in the virgin swampy jungle of the coastal plain, and in this respect it resembles *separatus*, while contrasting strongly with *umbrosus*.

Anopheles umbrosus.—The larvae of this species are found in the dense swampy jungle of the coastal plain, where the water is brown and peaty; they are seldom found outside the jungle, and then only under heavy shade. In this forbidding habitat the larvae have been found in small numbers in the innumerable pools. Mr. Reid informs me that from recent collections it seems likely that they should be looked for more in pockets along the edges of small, deep, slow-moving water-courses. *A. umbrosus* is also occasionally found in the foothills.

Anopheles brevipalpis is a rare species; it has been found breeding with both *letifer* and *umbrosus* on the coastal plain, in stagnant drains on rubber and coconut plantations, and in the jungle.

Anopheles roperi.—Reid notes that this species seems to be commonest in low, rolling, jungle country, such as that around Gemas and Bahau in Negri Sembilan, where the land is mostly from 100 to 300 ft. above sea level. The streams meander sluggishly through the jungle, and there are frequent shallow side channels, into which they overflow in wet weather. When such a stream subsides shallow pools are left in the storm-water channels, and decaying leaves soon collect in them. It is in these pools that *roperi* is principally found, though it sometimes appears in similar pools in shaded drains on rubber estates in this type of country. These temporary pools in the storm-water channels of jungle streams seem to be much favoured by the jungle-dwelling *Anopheles.* One such pool in jungle at Kuala Kubu, Selangor, yielded five species : *barbumbrosus* var., *leucosphyrus* (type form), *montanus*, *roperi* and *umbrosus.*

Too few specimens of *A. brevirostris* have been found for it to be possible to generalize about its breeding places. One recorded breeding place was in a small stream at the edge of jungle in the low foothills, another at Sijangkang on the coastal plain.

There is then a general resemblance between the breeding places of the various species of the *umbrosus* group, but each has its own preferred breeding places, and these preferences result in a characteristic zonation. *A. baezai* is confined to the brackish water zone ; *A. letifer* and *umbrosus* follow on the flat coastal plain, one in the open country and the other in virgin jungle, while *roperi* appears in the lower foothills. *A. separatus* occurs throughout much of this range, penetrating the fringe of the brackish water zone at one end and entering the foothills at the other, where there is also a certain intermingling of the two plains species. The two rare species, *albotaeniatus* and *montanus*, which are related to the *umbrosus* group, also breed principally in jungle ; *albotaeniatus* in the jungle of the plains and *montanus* in the jungle streams up to about 1000 ft.

3. Adult Habits.

The *Anopheles* of Malaya normally rest out of doors during the day, and the species of the *umbrosus* group are no exception in this respect. Nevertheless they are occasionally found in houses during the day, sometimes even in light and well-ventilated houses. Out of doors *umbrosus* can be found resting on the vegetation near its breeding places in the jungle. I have found small numbers of *letifer* on tree trunks and on vegetation in cultivated areas, but it cannot be said that the daytime resting places are known. *A. baezai* rests on the smooth bases of the fronds of nipah palm (*Nipah fruticans*) and in this situation I have taken it in considerable numbers during the early part of the day.

It is unusual for *Anopheles* to bite during the day in Malaya. In this respect *umbrosus* is exceptional ; in jungle it will feed at any time of day, often in company with the culicine *Mansonia* (*Mansonioides*) *longipalpis* V. d. Wulp. *A. letifer* will sometimes attack in shady situations or even in quite exposed places before the heat of the day, but this is unusual. Colless records *roperi* biting during the day, and other species of the series *Myzorhynchus*, *barbirostris*, *hyrcanus* and *albotaeniatus* will also occasionally do so.

Both *letifer* and *umbrosus* enter houses and bite freely from dusk to dawn. *A. umbrosus* is not confined to the jungle or its immediate vicinity, and will enter houses half a mile or more from the jungle edge, and will attack boldly, even under an electric light. When *umbrosus* settles to bite it can be seen that the dorsal markings form a definite pattern ; the white scales on the back of the head, the median ashy stripe on the mesonotum and the median area of the folded wings form a broad pale line, contrasting with the dark lateral areas of the mesonotum and the dark-scaled costas of the wings bounding it on either side.

Investigations made by Green and by the writer give evidence about the blood preferences of the common species. Table I shows the results of precipitin tests on mosquitoes trapped in the labourers' lines on Estate "Y" (Green, 1934, p. 107, and 1935, p. 27).

TABLE I.—*Results of Precipitin Tests on Mosquitoes Trapped in the Labourers' Lines of Estate* "Y," 1933 *and* 1934.

Species of *Anopheles*.	Number with human blood.	Number with animal blood.	Per cent. with human blood.
barbirostris	73	5	94
hyrcanus	7	9	.
karwari	18	5	.
maculatus	339	27	93
philippinensis	1	0	.
separatus	96	32	75
umbrosus	296	23	93

The following year, 1935, I continued the trapping on this estate, but abandoned precipitin tests in favour of comparing the relative abundance of the different species in the human bait trap[1] and at a nearby cattle shed; the results of this are shown in Table II.

TABLE II.—*Comparison of Catches in Human Bait Trap and Cattle Shed, Estate* "*Y*," 1935.

Species of *Anopheles*.	Human bait trap—per cent. of total trapped.	Cattle shed—per cent. of of total caught.
hyrcanus	23	30
karwari	13	20
maculatus	26	5
separatus	9	33
umbrosus	25	14
Total	665	470

Comparing these two tables it will be seen that there is a fair measure of agreement; both indicate that umbrosus and *maculatus* show a greater liking for human blood than do *separatus* and *karwari*. The method of comparing the catches from human and animal bait is probably the more informative and sensitive. As might be expected, the precipitin tests showed that most of the mosquitoes with blood caught from the human bait trap had taken human blood; *maculatus* and umbrosus gave the same figure, 93 per cent. Used in this way the precipitin test seems unlikely to detect any but large differences in blood preference; but if mosquitoes can be caught in their day-time resting places the test may be much more informative.

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[1] For a description of the human bait trap and the method of operation, see Gater, 1935, p. 80 and pl. 1, and Hodgkin, 1945, p. 44.

Table II suggests that *separatus* has a relative preference for cattle blood rather than for human, and that in this respect it resembles *karwari*, which has a somewhat similar status as a vector of malaria (see p. 329). On the other hand, umbrosus shows a relative preference for human blood, though from these results this does not appear to be as strong as that shown by *maculatus* (the proportions are 2 : 1 and 5 : 1 respectively). Unfortunately the identity of the umbrosus is uncertain; *letifer, umbrosus* and *roperi* were probably all present, with *letifer* predominating. In the collection of the Institute there is one specimen each of *letifer* and *roperi* from estate " Y."

TABLE III.—*Comparison of Catches in Human Bait Trap and Cattle Shed, Rantau Panjang, Selangor.*

Species of *Anopheles*.	Human bait trap—per cent. of total trapped.		Cattle shed—per cent. of total caught.	
	1938.	1939.	1938.	1939.
baezai . . .	28	44	10	3
barbirostris . .	10	22	2	2
hyrcanus . .	6	7	6	7
kochi . . .	5	6	19	15
sundaicus . .	6	1	8	1
vagus . . .	33	20	54	72
Total . .	501	543	655	543

Table III records similar information with regard to the blood preferences of *baezai* and other species occurring on the Selangor coast (Hodgkin, 1939 and 1940). *A. baezai* shows a relative preference for human rather than animal blood, and the same is true of *barbirostris* (which was probably mainly the vector form described as " dark winged " by Reid, 1941). Elsewhere, with larger numbers, *sundaicus* has also been found to show a relative preference for human blood. By contrast the two non-vector species *kochi* and *vagus* were relatively much commoner in the cattle shed than in the human bait trap, confirming evidence from elsewhere that they are markedly zoophilic.

4. RELATION TO MALARIA.

The work of Sir Malcolm Watson on the prevention of malaria on the coastal belt of Selangor early demonstrated the importance of umbrosus as a vector of malaria. The evidence was epidemiological; when habitations were sited more than half a mile from jungle and the cleared land properly drained there was little malaria; when they were close to the jungle malaria was intense. It is true that Watson (1911) found one umbrosus infected in ten dissected, but this in itself would be insufficient evidence on which to condemn a species.

The earlier records of dissections presumably refer principally to *letifer* and *umbrosus*, and although these and other species of the *umbrosus* group are confused, it is worth while briefly to summarize the dissections made before 1937.

TABLE IV.—*Results of Dissections of Wild Caught umbrosus*, 1911–1937.

Record.	Number dissected.	Number infected.	
		Mid gut.	Glands or both.
Various authors 1911/1928, from Gater (1935)	467	2	7
Hodgkin (1932/36)[1], various localities	517	.	1
Green and Hodgkin (1933/36)[1], Estate "Y"	2134	8	9
Field and Hodgkin (1935/6)[1], Estate "T"	3800	56	33

[1] Data from *Ann. Rep. I.M.R., F.M.S.*; dates refer to period of investigation.

Most of these mosquitoes were taken in the human bait trap, though a few were caught by hand in habitations. The practice in earlier investigations was to keep mosquitoes caught with blood in the gut for up to a week to allow this to be digested; from about 1937 all mosquitoes were dissected as soon as possible after capture, usually within 48 hours. The delay in dissection produces artificially high infection rates, a source of error that has been discussed elsewhere (Hodgkin, 1950).

From September, 1936, a distinction was made between *letifer* and *umbrosus*. There may still have been confusion with the rare species, but the numbers must have been too small to have altered greatly the detailed figures given in Table V. The figures are extracted from my records in the Annual Reports of the I.M.R.; the figures for *separatus* include dissections reported there by Green. Similar records for other common Malayan species are shown in Table VI.

TABLE V.—*Results of Dissections of Wild-caught Mosquitoes of the* Anopheles umbrosus *group.*

Species of *Anopheles*.	Date of investigation.	Place.	Number dissected.	Infections.[2]		Sporozoite rate per cent.
				Mid gut.	Glands or both.	
baezai	1935–1940	Rantau Panjang, Selangor (human bait trap)	1855	10	17	0·9
	1934–1940	Various	32	.	.	.
letifer	1936–1940	Estate "T," Banting, Selangor	8411	33	28	0·3
	1936–1940	Sijangkang, Selangor	4964	32	34	0·7
	1939	Estate "N.G.," Kuala Selangor, Selangor	433	1	1	+
	1936–1939	Various	438	1	.	.
separatus	1934–1936	Estate "Y," Puchong, Selangor	478	.	1	+
	1932–1940	Various	239	.	.	.
umbrosus	1936–1940	Estate "T," Banting, Selangor	3501	14	17	0·5
	1937–1939	Various	93	.	.	.

[2] Here and in Tables IV and VI mosquitoes with double infections are included once only—under "glands."

TABLE VI.—*Results of Dissections of Wild-caught Anopheles.*

Species of *Anopheles.*	Number dissected.	Infections.		Sporozoite rate per cent.
		Mid gut.	Glands.	
Estate "X" 1931/34 :				
maculatus, dissected immediately after capture	7315	12	37	0·5
karwari	3734	2	2	+*
philippinensis	2837	.	.	.
All records 1914/1940.				
kochi	1884	.	.	.

Before discussing Tables V and VI it will be convenient to present further data likely to have a bearing on the status of the species as vectors. Table VII shows the length of life of *letifer* and *separatus* in the laboratory (Green and Hodgkin, 1935, p. 41) ; figures for *maculatus*, *kochi* and *vagus* are included for comparison. There can be little doubt that the umbrosus of these experiments were *letifer*, since the imagines used were bred from larvae caught in the breeding places of that species. This applies equally to the experimental infections recorded in Table VIII.

TABLE VII.—*Length of Life in the Laboratory after One Blood Meal. Time in Days.*

Species.	Number observed.	Number living 16 days or more.	Range.	Mean age at death.
letifer	23	23	20–59	38
separatus	14	14	21–49	31
kochi	92	84	16–59	35
maculatus	121	117	16–66	35
vagus	63	55	16–36	24

In so far as laboratory conditions are any criterion it seems that both species readily live long enough for malaria parasites to complete sporogony. *A. letifer* was, on the average, the longest lived of all the species observed, *vagus* the shortest.

Table VIII summarizes the results of attempts made to infect the species experimentally by feeding them on malaria patients who had gametocytes in their blood, mostly those of *Plasmodium falciparum*. These attempts were made at various times between 1932 and 1941 in association with Drs. Green and Field ; most of these figures have been published in annual reports of the Institute.

Wherever possible *maculatus* and *kochi* were used as controls to *umbrosus* group mosquitoes, and in many instances they became infected from gametocyte carriers that failed to infect *baezai* and *letifer*.

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* See p. 328.

TABLE VIII.—*Results of Attempts to Obtain Experimental Infections.*

Species.	Number applied.	Number taking blood.	Number dissected.	Infections.		
				Gut.	Glands.	Total.
baezai . .	1300	225	188	1	1	2
letifer . .	683	297	278	9	1	10
separatus .	180[3]	95	67	0	0	0
umbrosus .	15	9	6	2	0	2
kochi . .	597	199	173	26	18	28
maculatus .	1216	571	490	85	92	121

With the foregoing as a background we can now discuss the part played by individual species in the transmission of malaria.

Anopheles baezai.—A comparatively high sporozoite rate (0·9 per cent.) is noted for this species in Table V. Despite this, however, the issue is not straightforward because—"The nature of the infections found in *A. baezai* remains in some doubt. The oöcysts and sporozoites do not seem to have quite the same appearance as those known to be of human origin; it is, however, difficult to define the difference, except that the gland infections seen in this species are frequently far heavier than those generally encountered. An attempt to infect two monkeys (*Macaca irus*) by injecting sporozoites found in wild-caught *A. baezai* was unsuccessful. Monkeys of this species are common at Rantau Panjang, and of thirteen examined, eleven were found with light infections of *Plasmodium* spp. Precipitin tests on blood from a few *A. baezai* which were caught with fresh blood showed that all had fed on cattle or goats. The examination of blood from three head of cattle and sixteen goats stabled near the trap showed *Babesia*-like parasites in the blood from the cows, but the goats' bloods were negative. Comparative catches in the trap and in cattle sheds during 1938 and 1939 (Table III) showed that *A. baezai* is attracted to human beings more than are the other local species (except *A. barbirostris*)" (Hodgkin, 1941, p. 55).

This raises two questions: firstly, the identity of the parasites found in the mosquitoes, and secondly, the feeding habits of the mosquito. On the first little more can be said; the human population in the vicinity of the trap was small, and malaria was not intense; small numbers of two other vectors, *barbirostris* and *sundaicus*, were also present, but *baezai* was the only species found infected at this site. On the second point it may be noted that while the few precipitin tests that it was possible to make appeared to show a preference for cattle blood, the comparative catches (Table III) suggest the opposite. Here, as elsewhere (e.g. Table II), known vectors of malaria appear to show a relative preference for human blood when compared with those that do not normally transmit malaria; *baezai*, like *maculatus*, *barbirostris* and *sundaicus*, goes more freely to the human bait trap than do such species as *karwari*, *kochi* or *vagus*. It must therefore be assumed that there is at least the necessary contact with man that is required to make transmission possible.

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[3] This figure includes 112 applied by Pendlebury (1927), of which 69 took blood and 41 were dissected. Barber (1918) applied *hunteri* (presumably *separatus*); out of 8 dissected one had one oöcyst.

The attempts to infect *baezai* (Table VIII) give little support to the belief that it is a vector. Only a small proportion (17 per cent.) of those applied to gametocyte carriers would feed under the experimental conditions, and of 188 that fed only two became infected. However, experience with other species leads one to doubt the value of such data. On the one hand, *kochi*, which has never been found naturally infected in Malaya, is as readily infected in the laboratory as *maculatus*. On the other hand, it is beyond doubt that *letifer* is a vector, but it is difficult to infect experimentally. The same is true of the dark-winged form of *barbirostris*, and possibly also of the other members of the *Myzorhynchus* series. Barber (1918) says of umbrosus (presumably *letifer*) that its susceptibility to artificial infection is relatively low, and Stanton (1912) records that he was able to infect *aconitus*, *philippinensis* and *maculatus* from a crescent carrier, but not umbrosus (*letifer*) in 5 trials, *barbirostris* (8 trials) or *hyrcanus*.

One further observation is relevant, though it is difficult to know what significance to attach to it. During 1940 *baezai* were caught regularly on nipah palms that were growing near the trap. Both these mosquitoes and those caught in the trap were dissected within 48 hours of capture (usually less), with the following results :

	Number dissected.	Oocyst rate per cent.	Sporozoite rate per cent.
Caught on nipah	2388	3·4	3·8
Human bait trap	792	1·5	1·6

The difference in infection rates is considerable, and I attribute it to there being a larger proportion of newly emerged imagines amongst those caught in the trap than in the hand catches on the nipah. Among the mosquitoes caught on the nipah the sporozoite rate rose from nil where the wing-fringe was complete, to 20 per cent. when no fringe remained. Unfortunately there were not enough *baezai* entering the trap at the time to compare the relative ages of those in the trap with those in the hand catches, as evidenced by the degree of damage to the wing fringes.

The experience of Hacker (1920) in the investigation of an outbreak of malaria at the mouth of the Perak River is interesting, and I quote from Reid (personal communication) : "Hacker concluded, probably correctly, that *A. sundaicus* (his *ludlowi*) was the cause chiefly because the area covered by the outbreak coincided with the distribution of *sundaicus*, whilst umbrosus was as common further up the river beyond the affected area as within it. However, examination of some of his specimens in 1941 showed, as might be expected, that he was dealing with both *baezai* and *letifer*. A specimen from Rebana estate well up the river, which was not affected by the outbreak and had a typically fresh-water fauna, was *letifer* ; four specimens from Bagan Datoh, Kayan, and Bagan Gajah in the middle of the affected area where the water is brackish, were *baezai*."

It may be concluded then that despite the high sporozoite rates recorded for *baezai* its status as a vector of malaria remains uncertain in the absence of confirmatory epidemiological evidence. Until such evidence is forthcoming it will be well to assume that it will transmit human malaria when it is abundant. Actually it is restricted in its distribution and is seldom common.

Anopheles letifer.—The dissection records in Table V relate principally to two localities, estate T and Kampong Sijangkang. The two places are within a few miles of one another in the Selangor coastal plain south of Klang; the first is a plantation on low hills surrounded by swampy jungle in which *umbrosus* breeds, while Sijangkang is quite flat, only a few feet above sea level, and carries a dispersed population of Javanese, who cultivate coconut, pineapple, rubber and coffee. The estate was the site of experiments with drug prophylaxis (Field *et al.*, 1937), and the lower sporozoite rate is possibly attributable to the use of the drugs. Among 2248 *letifer* dissected during periods when there was no prophylaxis the sporozoite rate was 0·8 per cent.

Sijangkang is of particular interest, because *letifer* is practically the only anopheles occurring there; during five years of trapping while nearly five thousand *letifer* were caught only 50 specimens of six other species were taken. The soil is almost pure peat, some 5 or 6 ft. deep, overlying the grey coastal clay; there are numerous agricultural drains and household wells filled with brown acid water in which *letifer* breeds freely. Spleen and parasite surveys of about 130 school children were made by Field (*Ann. Reps. I.M.R.*), with the following results:

	Spleen rate per cent.	Parasite rate per cent.
1936	71	44
1939	67	40
1940	48	22

The figures indicate moderate to severe endemic malaria. From 1936 to 1938 the trap catches of *letifer* averaged only three a night, but in February, 1939, the trap was moved to a new site and the catches jumped to an average of twelve a night, which, with a sporozoite rate of 0·8 per cent., indicates a high rate of transmission (an average of one infective mosquito every eleven nights).

It may be said, therefore, that *letifer* is an important vector of malaria; the detailed parasitological and epidemiological evidence from Sijangkang and the previous experience of those concerned with the prevention of malaria in the field put this beyond any doubt. Economically it is probably now the most important vector of the *umbrosus* group, because its breeding habits bring it into close association with man, whilst *umbrosus* is confined to the vicinity of jungle.

It is interesting to note in conclusion that in each of the malaria surveys at Sijangkang, and in a neighbouring settlement where *letifer* was also the vector, Field found *Plasmodium malariae* to be the predominant parasite.

Anopheles separatus.—There are no epidemiological grounds for believing that this species is a vector of malaria. Only one infected specimen has been recorded (Table V), a gland infection found by Green (1935). This may well be of the same anomalous nature as the two gland infections found in *karwari* (Table VI). In the latter case the infected specimens had been kept in the laboratory for a week or more before they were dissected. If this were true also of the one infected specimen of *separatus*, then neither species has yet been proved to be a vector of malaria in nature.

Although we have so far failed to infect *separatus* experimentally, it is evident that it is capable of transmitting malaria parasites (Tables V and VII). However, since it is more zoophilic in its feeding habits than are the known vectors (Tables I and II), is seldom abundant, and has never been suspected on epidemiological grounds, we may conclude that normally it takes no part in the transmission of malaria in Malaya.

Anopheles umbrosus.—On epidemiological grounds this species has long been regarded as an important vector of malaria. In the early days of the plantation industry it was probably the principal vector on the estates that were being hacked out of the jungle swamps along the coast, and it seems certain from Watson's descriptions (1921) that this mosquito was then abundant. He observed that in such places the intensity of malaria in the labour forces under his control was in inverse proportion to the distance of their living quarters from the jungle edge. *A. letifer* was no doubt also present and transmitting malaria, but on the plantations of the coastal plain good agricultural drainage served to keep the breeding of this species in check.

The parasitological evidence comes only from Estate " T," and is not completely satisfactory. The estate is surrounded by jungle swamp, and the cleared ground forms a small island of low hills on which there was no breeding of vector *Anopheles* until *Anopheles* appeared in 1938. In the drains round the estate boundary *letifer* bred freely, while a few yards away there was jungle swamp with extensive breeding of *umbrosus*. Both species were caught in considerable numbers in the labourers' " lines " not a quarter of a mile from the jungle edge, and both were found infected with oöcysts and sporozoites of *Plasmodium* (Table V). *A. letifer* is known to be a vector, and the possibility must be envisaged that it was the only carrier of human malaria on the estate, the infections in *umbrosus* being the parasites of monkey malaria. However, in view of the fact that *umbrosus* was feeding readily on human beings, it may be assumed that a proportion of the infections were with human species of *Plasmodium*. During periods of drug prophylaxis 1336 *umbrosus* were dissected and two were found with sporozoites, while during periods when there was no prophylaxis 1493 were dissected and 7 were found infected. These figures appear to support the other evidence that *umbrosus* was transmitting human malaria on this estate, though clearly the difference is not significant statistically.

Attempts to infect *umbrosus* experimentally have been too few for the lack of infections to have significance (Table VIII). The results of further attempts during 1941 do not appear to have survived the Japanese occupation.

Both on epidemiological and parasitological grounds therefore we may conclude that *umbrosus* is an important vector of malaria, although its sphere of influence is confined to the immediate vicinity of jungle swamp. Occurring, as it often does, alongside *letifer*, it is frequently associated with intense malaria such as that on Estate " T " immediately before drug prophylaxis commenced, when an average of one infective umbrosus a night was taken in the trap.

I am obliged to Mr. Reid for the following notes with reference to the remaining species of the *umbrosus* group : " Nothing is known about the adult habits of *brevirostris*, *hunteri*, or *similissimus*, and *brevipalpis* is clearly a species which seldom attacks man and is usually uncommon. Roper found about

35 specimens of *brevipalpis*, mostly females, resting in a building 150 yards from the jungle and 200 yards from a swamp; he dissected five, but found no infections. Strickland (1915) seems to be the only person who has recorded *brevipalpis* attacking man. He took nine specimens in two nights at Morib, Selangor, where there was an outbreak of malaria at the time; he dissected 140 *sundaicus* and *umbrosus* without finding an infected specimen, and concluded that *brevipalpis* was possibly the cause of the outbreak. It seems, however, improbable that this species is ever of importance as a vector.

"*Anopheles roperi.*—There is little information about *roperi* because it has been confused with *umbrosus* and *letifer* in the past. Colless, in North Borneo, has taken it biting by day, and informed me (*in lit.*) that he found one gut infection among four dissected, *umbrosus* being the principal vector at the time. It is perhaps suggestive that *roperi* has been found repeatedly at Gemas, on the borders of Negri Sembilan and Johore, where malaria has always been difficult to control. Hacker (1919) investigated malaria at this place and found *maculatus* in the open and umbrosus in the low-lying jungle, besides other species. Four of his specimens of umbrosus from Gemas are in the collection of the Institute for Medical Research and all are *roperi*. Seventeen specimens collected in 1946 are *roperi*, and a further one in 1947. It is possible that *maculatus* has been responsible for all the malaria here, but in that case it is difficult to see why the usual measures against this species should have been less successful here than elsewhere, especially as the town is largely surrounded by jungle, which affords no breeding places for *maculatus*. Local report makes it clear that larvae of umbrosus (presumably *roperi*) are at times abundant in the low-lying jungle, and the type of country appears to be ideal for this species. Control by canalization and oiling of the slow moving jungle streams has now been undertaken.

" Hacker found that umbrosus was common in the low-lying jungle round Gemas, and that ' it is not necessarily limited to the coastal area, as commonly stated, but may be found plentifully as far inland as Gemas ' (about 35 miles). The reason for this remark is of some historical interest. Watson had shown that umbrosus was the principal vector on the flat coastal plain of Selangor, and that clearing the jungle and draining the land removed it. When he began to apply these measures in the foothills *maculatus* appeared in the cleared ravines and proved a much worse scourge than umbrosus. Watson soon realized what was happening and turned his attention to measures for controlling *maculatus*, but he still assumed that hilly jungle, like the flat jungle, contained umbrosus and would be malarious. When Strickland came to Malaya Watson suggested to him that he might test this assumption. Strickland did so and found that on the contrary hilly jungle appeared to be in general very free of dangerous *Anopheles*, and he could only find occasional umbrosus-like larvae. Accordingly he declared (Strickland, 1916) that umbrosus was absent from the inland hills, and that these hills were non-malarious when covered with virgin jungle. In general this is true of the rather steep hills that flank the main range, and we have seen (p. 3) that *umbrosus* and *letifer* are principally mosquitoes of the coastal plains and only found in small numbers in the hills. At Gemas, however, Hacker was in the low rolling country that lies east of the main range beyond its termination in Negri Sembilan, and he had found a mosquito (*roperi*) which appears to be commonest in this type of country and absent from the flat coastal plains.

" Roper, in North Borneo, found umbrosus infected, and he was the first to draw attention to this large form, but it seems fairly clear from his paper that *roperi* formed only a small proportion of his umbrosus, which were probably mostly *umbrosus* Theo., since the adults were common, but he could not find the larvae."

Periodicity of the Vector Species.

The malaria of hilly districts where *maculatus* is the vector shows a marked periodicity, with the peak incidence about May. With the multiplicity of carriers on the coast it is not to be expected that any periodicity will be so evident. In the Selangor coastal districts the peak incidence of malaria usually comes about November (Hodgkin, 1945). The limited observations suggest that *letifer* is rather more abundant during the last four months of the year than at other times, perhaps associated with the heavier rainfall then. The same may be true also of the " dark-winged " *barbirostris*. On estate " T " *umbrosus* was usually present from December to May, while during the other six months of the year very few were caught ; in the drier weather from June to August or September there was little water in the jungle, and it was some time before the swamps filled up and this species re-established itself. *A. sundaicus*, and probably also *baezai*, are most abundant about the time of and following the high tides of the September equinox, when rainfall is usually heaviest.

5. SUMMARY.

1. The mosquitoes of the *Anopheles umbrosus* group are Oriental in distribution and are commonest in the Malaysian sub-region.

2. In Malaya the larvae are found in water that is stagnant or slowly moving, usually on the acid side of neutrality, seldom exposed to the full sun and often in jungle or under other heavy shade. The various species have preferred breeding places that result in a characteristic zonation : *baezai* in brackish water along the coast, *letifer* in pools and drains in cultivated land on the plains, *umbrosus* in jungle swamp on the plains, *roperi* in the foothills, and *separatus* scattered throughout much of this range outside the jungle.

3. Both *letifer* and *umbrosus* feed readily on man, and the latter species will attack by daylight in the jungle. It seems probable that *baezai* and *roperi* also feed readily on man ; *separatus*, on the other hand, tends to be zoophilic.

4. *A. letifer* is an efficient vector of malaria, and at the present time it is economically the most important species of the *umbrosus* group in Malaya. *A. umbrosus* is also an important vector, but its distribution is restricted to jungle swamp and its immediate vicinity. The status of *baezai* requires further investigation ; for the present it will be well to suspend judgment, while remembering that the evidence suggests that it is a vector in those few localities where it is abundant. It seems probable on epidemiological grounds that *roperi* is also a vector where it is common. *A. separatus* does not appear to take any part in the transmission of malaria in Malaya.

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A REVISION OF THE GENUS *LIPOSCELIS* MOTSCHULSKY WITH NOTES ON THE POSITION OF THIS GENUS IN THE ORDER CORRODENTIA AND ON THE VARIABILITY OF TEN *LIPOSCELIS* SPECIES.

By Edward Broadhead, M.A., D.Phil.
(*Department of Zoology, Leeds University.*)

Manuscript received 28th March, 1950.
(Read 3rd May, 1950.)

With 3 Plates and 28 Text-figures.

Introduction.

The aim of the present paper is threefold—firstly to assess the validity of two of the major groupings of the Corrodentia proposed by Pearman (1936), secondly a taxonomic revision of the 22 species of this genus, and thirdly a comparison of the variability of the parthenogenetic *L. bostrychophilus* with those of nine bisexual species and a comparison of the variability of the two sexes in nine of the species.

The Position of *Liposcelis* in the Corrodentia.

Pearman (1936), in revising the classification of the Order, proposed eight major groupings, these being based on a number of exoskeletal features, including the mouth-parts. The families belonging to these major groups were listed and in each family a few genera were selected as typical forms. The first group, the Atropetae, comprises the families Lepidopsocidae, Atropidae and Psoquillidae, and the second group, the Nanopsocetae, includes only the two families Pachytroctidae and Liposcelidae. No characters were given by Pearman. Menon (1942) has reviewed the Nanopsocetae in a study based largely upon Indian representatives of the group. Pearman's classification has been adopted by Badonnel (1943) who provides brief details of family characters, and Roesler (1944) has maintained the Atropetae and Nanopsocetae in a modified classification including all the known genera.

A characterization of the Nanopsocetae, of the Liposcelidae and of the genus *Liposcelis* is given below. In order to indicate more clearly the position of *Liposcelis* in the group, the Atropetae, the Pachytroctidae and the genus *Embidopsocus* are also defined. These are based on the following representative genera, specimens of which have been examined by me: Atropetae—*Soa*, *Nepticulomima*, *Pteroxanium* (= *Lepidilla*), *Lepolepis*, *Psoquilla*, *Trogium*, *Cerobasis* (= *Hyperetes*) and *Lepinotus*; Nanopsocetae—*Nanopsocus*, *Embidopsocus* and *Liposcelis*. Consideration has been given to the remaining genera of the Nanopsocetae from descriptions in the literature.

Group ATROPETAE Pearman, 1936.

Antennae with more than 15 segments (20–50 segments). Flagellar segments with no annulations. Mandibles of characteristic shape—in right mandible the margin between the base of the molar area and the point of insertion of the adductor muscle strongly concave; in left mandible at anterior end of molar area a single large tooth directed dorsally and posteriorly (fig. 1). A single short stout spur on the second segment of the maxillary palpus (fig. 2) Maxillary pick typically with three tines; one of these arises from the basal half of the longest and may be considerably reduced or absent; longest tine bifid at its tip. Labial palpi 2-segmented. Always two very strong spurs on apex of hind tibia. Three tarsal segments in adult, two in nymph. Claws typically either with a preapical tooth and with a long setiform process at the base or with no preapical tooth but at the base with a long curved finger-like process truncated at its tip. Paraproct produced at its tip into a long strong spur. Female genitalia fully exposed ventrally and consisting of one pair of gonopods only, the 3rd valvulae, these long and cylindrical, bearing many long bristles; 1st and 2nd pairs of valvulae vestigial or absent.

All the members of this group have the body and legs thickly set with long bristles and often also with scales. The wings are variable, two pairs with relatively complete venation (most LEPIDOPSOCIDAE), or a single pair of scale-like wings with no veins (*Trogium*, *Lepinotus*, *Lepolepis*), or occasionally (*Cerobasis*) the wings reduced to a pair of small knobs. The majority of the above listed features are characters on which great weight must be placed in determining affinity, many being peculiar to the group. The ATROPETAE must then be regarded as a very homogeneous group, thus supporting Pearman's classification in this respect.

Group NANOPSOCETAE Pearman, 1936.

Antennae with 15 segments (subject to considerable individual variation). Some or all of the flagellar segments with annulations. Mandibles of characteristic shape—in right mandible the margin between the base of the molar area and the point of insertion of the adductor muscle convex; in left mandible, in addition to the broad two-pointed tooth at the anterior end of the molar area, a curved blunt tooth overlying dorsally the central portion of the molar area (fig. 3). Never a stout spur on second segment of maxillary palpus. Maxillary pick typically with three tines, the longest tine single or bifid at its tip, one of the shorter tines may be considerably reduced. Labial palpi one-segmented.[1] The number of strong spurs on apex of hind tibia variable—two, one or none. Three tarsal segments in adult, two in nymph. Claws always with one preapical tooth, between this and the base of the claw fine teeth or completely smooth; never a long setiform or finger-like process at the base. No apical spur on paraprocts. Female genitalia situated underneath the subgenital plate and composed of reduced 1st, 2nd and 3rd valvulae, all of similar length; 3rd valvula flat and leaf-like; both 2nd and 3rd valvulae hairless.

Some of the members of this group are entirely apterous in both sexes (*Liposcelis*), others have a pronounced dimorphism with apterous and alate females and apterous males (*Embidopsocus*, probably also *Pachytroctes*, *Peritroctes* and *Psacadium*). The wings of *Tapinella* and *Embidopsocus* are held flat over the back when at rest, not roofwise, as in other Corrodentia.

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[1] There are several statements in the literature that various species of this group have 2-segmented palpi, viz. Badonnel (1943) on PACHYTROCTIDAE, and Menon (1941) on NANOPSOCETAE. The palpi are one-segmented in *Liposcelis*, *Embidopsocus* and *Nanopsocus*. Reference has been made to the reason for this difference of opinion by Broadhead and Hobby (1944).

The two families of the NANOPSOCETAE, the PACHYTROCTIDAE and LIPOSCELIDAE, differ widely in general facies, the latter flattened with an elongate-oval abdomen and relatively short legs and antennae, the former not flattened, with a much more globular abdomen and relatively longer legs and antennae. The venation is different in the two families owing to the differing degree of reduction of the veins. The 15-segmented antennae, the one-segmented labial palpi, the shape of the mandibles and the nature of the female genitalia are important indications, however, of their affinity. The resemblance of apterous members of the PACHYTROCTIDAE to some ATROPETAE in general facies is, therefore, purely superficial. It is also of interest to note that the dimorphism involving winged and apterous females occurs in both families.

Family PACHYTROCTIDAE Enderlein, 1927.

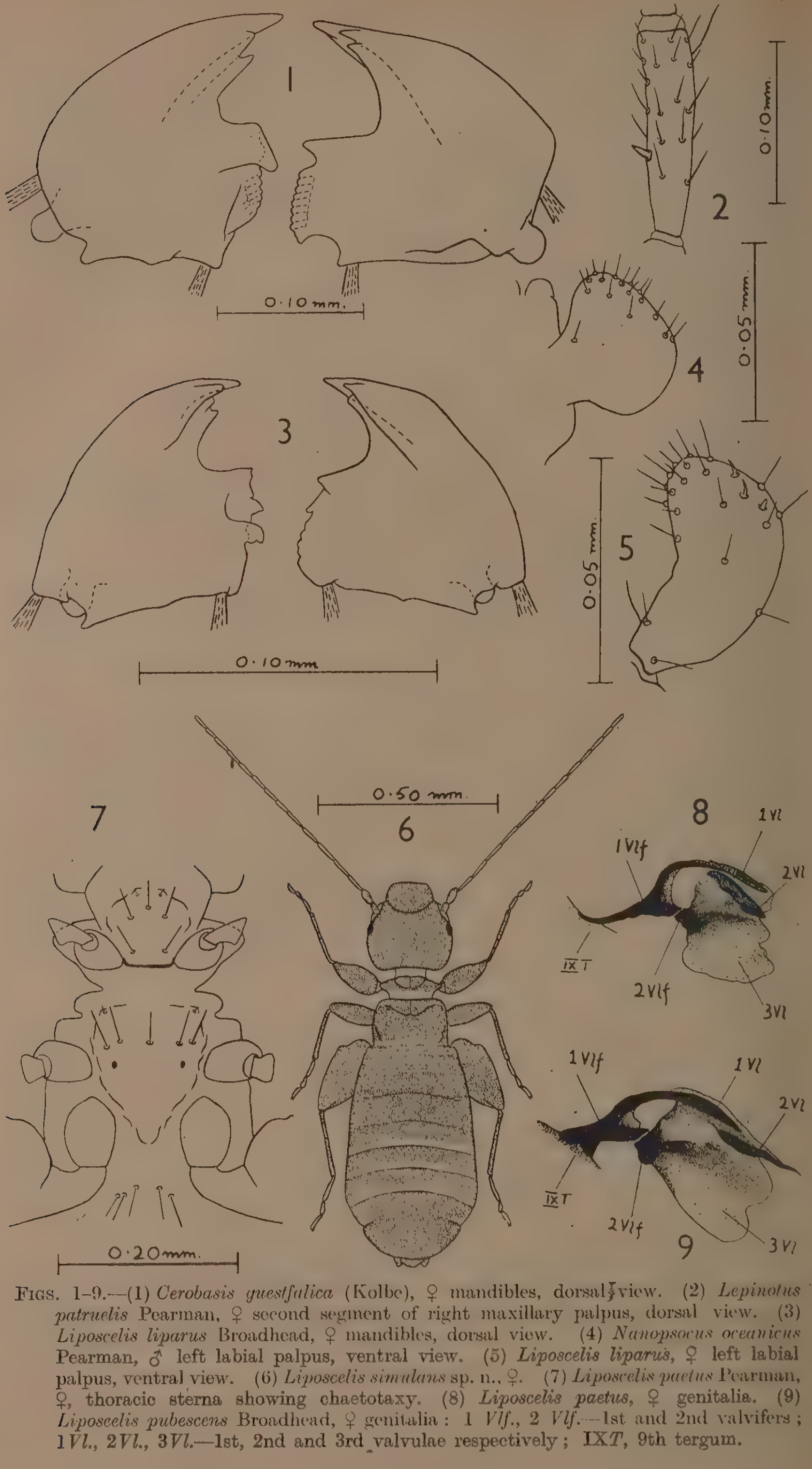
Body not depressed, abdomen subglobular, hind legs usually extending beyond apex of abdomen, antennae longer than three-fourths of body length. A pronounced, but short coronal suture in both apterous and winged forms, but frontal sutures absent or very indistinct. Three ocelli in winged forms, none in apterous forms. Compound eyes always relatively large and hemispherical in both apterous and winged forms, with a large number of ommatidia. Eyes may or may not extend backwards as far as hind angle of head. Proximal flagellar segments (the first 4 or 5) of antennae not annulated, more distal segments with annular rings formed by closely-set microtrichia. Labial palpi of characteristic shape (fig. 4)—sharply angled (known only in *Nanopsocus* and in *Pachytroctes aegyptius* Enderlein and *ealensis* Badonnel). Pronotum flat, transversely rectangular with no subdivisions. Meso- and metanota separate in both winged and apterous forms, with the usual notal divisions in winged forms, uniformly sclerotized with a complete transverse suture in apterous forms. Hind femur not dilated more than fore or mid femur, and not fused to hind trochanter. Wings elongate, rounded apically ; pterostigma undifferentiated and with no stigma sac ; in fore wing Rs and M each forked only once, areola postica long and rectangular, 1A and 2A ending separately on the wing margin ; in hind wing no closed basal cell. Abdominal terga membranous or only basal and apical terga sclerotized.

Representative genera are *Pachytroctes* Enderlein, 1905, *Psacadium* Enderlein, 1908, *Peritroctes* Ribaga, 1911, *Nanopsocus* Pearman, 1928, and *Tapinella* Enderlein, 1908. An alary dimorphism in the female sex is likely to be found in many species. winged and apterous females being recorded for *Pachytroctes ealensis* Badonnel, 1949, and winged females and apterous forms (sex undetermined) being recorded by Menon (1938) for *Psacadium georgi* and *Peritroctes cochinensis*.

Fossil members of the group are *Palaeotroctes succinicus* (Hagen, 1882), from Copal, and *Sphaeropsocus künowi* Hagen, 1882, from Baltic Amber (Lower Oligocene). *Palaeotroctes* approaches the LIPOSCELIDAE in the fusion of the meso- and metanota and in the small eyes with relatively few facets. *Sphaeropsocus*, although possessing the majority of the typical Pachytroctid features listed above is highly aberrant in the presence of only a single pair of elytra-like wings and, like *Palaeotroctes*, approaches the LIPOSCELIDAE in certain respects. In the living species *S. recens* Hickman, 1934, the eyes are small and composed of only ten ommatidia and the meso- and metanota are fused.

Family LIPOSCELIDAE Enderlein, 1911, 1927.

Body strongly depressed dorso-ventrally, abdomen elongate-oval, hind legs not extending beyond apex of abdomen, antennae relatively short of length, half to three-fourths of



FIGS. 1–9.—(1) *Cerobasis guestfalica* (Kolbe), ♀ mandibles, dorsal view. (2) *Lepinotus patruelis* Pearman, ♀ second segment of right maxillary palpus, dorsal view. (3) *Liposcelis liparus* Broadhead, ♀ mandibles, dorsal view. (4) *Nanopsocus oceanicus* Pearman, ♂ left labial palpus, ventral view. (5) *Liposcelis liparus*, ♀ left labial palpus, ventral view. (6) *Liposcelis simulans* sp. n., ♀. (7) *Liposcelis paetus* Pearman, ♀, thoracic sterna showing chaetotaxy. (8) *Liposcelis paetus*, ♀ genitalia. (9) *Liposcelis pubescens* Broadhead, ♀ genitalia : 1 *Vlf.*, 2 *Vlf.*—1st and 2nd valvifers ; 1*Vl.*, 2*Vl.*, 3*Vl.*—1st, 2nd and 3rd valvulae respectively ; IX*T*, 9th tergum.

body length (fig. 6). Epicranial suture either completely absent or indicated only superficially by a break in the sculpturing of the cuticle. Three ocelli in winged forms, none in apterous forms. Compound eyes large and hemispherical in winged forms, with a large number of ommatidia ; small in apterous forms, with 2–8 ommatidia ; eyes never extending backwards as far as hind angle of head. All the flagellar segments of the antennae with annular rings formed by closely-set microtrichia. Labial palpi of characteristic shape (fig. 5) and with a group of 3 external subapical sense cones (sensilla basiconica of Snodgrass), the two more apical ones pointed, slightly curved and about half as long as adjacent hairs, the third broader and blunter and shorter than the other two. Pronotum divided by furrows into 3 lobes, the median lobe with a more superficial medial longitudinal line (fig. 10). Meso- and metanota separate in the winged forms and with the usual notal divisions ; fused in the apterous forms with only an incomplete faint transverse sutural depression (fig. 10). Sterna of meso- and metathorax completely fused in both winged and apterous forms. Hind femur more dilated than fore or mid femur, and fused to hind trochanter, only a superficial line of demarcation present between them. Wings very elongate, rounded apically ; veins represented by very indistinct thickenings of wing membrane ; venation very much reduced, in fore wing R and M both unbranched, long, but not reaching wing margin, Sc only slightly developed ; in hind wing R long, but not reaching wing margin, Sc and M scarcely indicated. Abdominal terga uniformly, although lightly, sclerotized. Ten abdominal segments (excluding epiproct and paraprocts), in female 8th and 9th terga fused medially, 9th and 10th completely fused, in male 9th and 10th terga fused medially.

The LIPOSCELIDAE comprise two distinct genera, *Embidopsocus* Hagen, 1866, with 12 species and *Liposcelis* Motschulsky, 1853, with 24 species. Two other genera, *Belapha* Enderlein, 1917, and *Belaphotroctes* Roesler, 1943, each with two species, are closely allied to *Embidopsocus*, resembling the latter in most of the characters listed below, but possessing a few highly specialized features, notably the enlargement of the terminal segment of the maxillary palpus. The relationship of the genera in this family would, therefore, be better expressed in the classification by regarding *Belapha* and *Belaphotroctes* as subgenera of *Embidopsocus s. lat.* The chief characteristics of *Embidopsocus s. str.* and of *Liposcelis* are given below.

Embidopsocus Hagen, *s. str.*

Embidopsocus Hagen, 1866, *Ent. mon. Mag.* **2** : 170.
Tropusia Hagen, 1883, *Stenotroctes* Enderlein, 1905, *Embidotroctes* Enderlein, 1905, *Trigonosceliscus* Enderlein, 1910.
Genotype : *Embidopsocus luteus* Hagen, 1866, by monotypy.

Diagnosis of *Embidopsocus* Hagen, *s. str.*

Extremely depressed. Males apterous, but females, in some species at least, dimorphic, winged and apterous, with no intermediates. Cuticle on dorsal surface of body usually smooth or with fine arched ridges. Epicranial sutures completely absent in both winged and apterous forms. Three dorsal ocelli in winged forms ; none in apterous forms. Eyes hairless and with many ommatidia in winged forms ; two ommatidia in each eye in apterous forms. Median lobe of pronotum either elongate and bordered laterally with a strongly sclerotized internal ridge of cuticle or (as in *oleagina*) transversely oval. Margin of lateral lobes of pronotum rounded with coxal attachment lateral and partly visible from above. In apterous forms relative size of anterior areas on meso-metanotum characteristic—the transverse furrows typically situated almost mid-way between anterior and posterior margins of fused meso-metanotum (fig. 10*a*); in winged forms, mesothoracic region greatly enlarged and the tergal areas similar to those of other winged Corrodentia. Mid-coxae typically situated almost half-way between anterior and posterior margins of meso-metanotum, coxal attachment lateral and partly visible from above. A sclerotized intersegmental plate between pro- and meso-metathoracic sterna. Hind femur without a dorsal protuberance at its greatest breadth. A single stout spur on distal end of hind tibia on its inner side. Hind tibiae with very long setae, as long as, or longer than, first tarsal segment, as well as short hairs. The bristles on the last three abdominal segments pointed apically. No internal **T**-shaped skeletal structure towards apex of subgenital plate of female. Female genitalia having 1st valvifer not **Y**-shaped, but short and broadly fused to lateral margin on 9th tergum. Male genitalia: the basal segment of the clasper very broad, much broader than the terminal segment.

Liposcelis Motschulsky.

Liposcelis Motschulsky, 1853 *Études entomologiques* **1**: 19. (Genotype: *Liposcelis brunneus* Mots. by monotypy, *L. museorum* Mots., being a *nomen nudum.*)
Termes Müller, 1776, *Zool. Dan. prod.*: 184 *nec* Linnaeus, 1758, *Syst. Nat.*, 10th ed.: 609. (Genotype: *Termes fatale* L., see Snyder, 1949: 178.)
Trogium auct. nec Illiger, 1798, *Verz. Käf. Preuss.*: 500. (Genotype: *Hemerobius pulsatorius* F. by monotypy.)
Atropos auct. nec Leach, 1815, *Edinburgh Encycl.* **9** (1): 139. (Genotype: *Termes lignarium* Deg. = *T. pulsatorium* L. by monotypy.)
Troctes auct. nec Burmeister, 1839, *Handb. Ent.*: 773–5. (Genotype: *Termes pulsatorium* L. designated by Gurney, 1939, *J. Wash. Acad. Sci.* **29**: 510.)

The specific identity of the genotype, *L. brunneus*, is uncertain, but it is reasonably certain that it is congeneric with the species listed below.

Diagnosis of *Liposcelis* Motschulsky.

Moderately depressed and completely apterous in both sexes. Cuticle on dorsal surface of body sculptured with arched ridges or minute tubercles or both. Epicranial suture either absent or represented only by a break in the sculpturing. No dorsal ocelli. Two to eight ommatidia in each eye. Median lobe of pronotum transversely oval. Margin of lateral lobes of pronotum acute with coxal attachments ventral and not visible from above. Relative size of anterior areas on mesonotum characteristic—the transverse furrows situated anteriorly and almost reaching the antero-lateral angle of the fused meso-metanotum (fig. 10*b*). Mid-coxae situated near anterior margin of meso-metathorax, coxal attachment ventral and not visible from above. No sclerotized intersegmental plate between pro- and meso-metathoracic sterna. Hind femur with a dorsal obtuse protuberance at its greatest breadth. No stout spur on distal end of hind tibia (at most with two very short bristles little thicker than adjacent hairs). Hind tibiae with hairs of uniform length, these much shorter than first tarsal segment. The bristles on the last three abdominal segments truncated apically. An internal **T**-shaped skeletal structure towards apex of subgenital plate of female. Female genitalia: 1st valvifer long and **Y**-shaped, the base of the "**Y**" fused narrowly with the lateral margin of the 9th tergum (figs. 8, 9). Male genitalia: The basal segment of the clasper narrow, about as broad as the terminal segment.

COMPARISON OF SOME STRUCTURAL FEATURES OF *Embidopsocus* AND *Liposcelis*.

Some of these generic characteristics can be correlated with the mode of life of these creatures. Although *Liposcelis* shows a greater degree of specialization in the total loss of wings, *Embidopsocus* appears to be more specialized

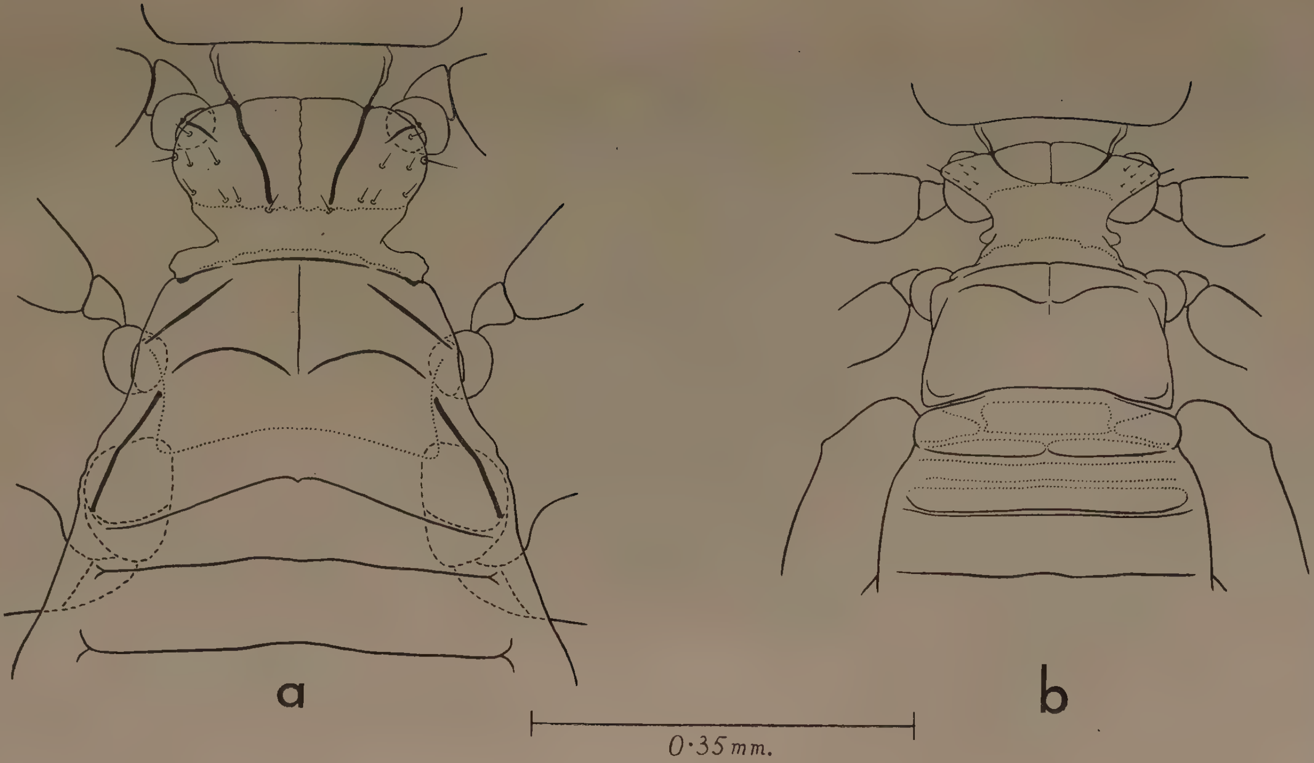


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FIG. 10.—Dorsal view of thorax and anterior abdominal segments: (*a*) *Embidopsocus enderleini* (Ribaga), apterous ♀ (dots indicate limits of sclerotization, the broken lines mark the position of structures ventrally). (*b*) *Liposcelis subfuscus* Broadhead, ♀ (dots indicate the limits of sclerotization).

for life in restricted crevices under the bark of trees. With the greater flattening of the body in *Embidopsocus* can be correlated certain of the characteristic features of the thorax (see fig. 10). In *Liposcelis* all the coxae are situated ventro-laterally, the points of articulation of the coxae with the thorax not being visible from above. The sclerotized struts, which articulate with the base of the mid and hind coxae and which thus provide a certain rigidity to the otherwise lightly sclerotized thoracic terga and sterna, lie in the somewhat deep lateral face of the meso-metathorax. In *Embidopsocus*, as typified by *E. enderleini*, the fore and mid coxae project laterally from the body and their more dorsal points of articulation with the thorax are visible from above. The longitudinal sclerotized struts between the mid and hind coxae are clearly visible through the dorsal surface of the meso-metathorax near its lateral margin.

Apart from these characters, which are clearly highly specialized features, *Embidopsocus* must be regarded as more primitive than *Liposcelis*. In the latter genus the total loss of wings is a secondary feature. The dimorphic females of *Embidopsocus* have already been remarked upon (Broadhead, 1947*c*). The winged condition in psocids is more primitive than the apterous, and the winged females of *Embidopsocus* approach more closely in structure those of other winged psocids, although the venation is extremely reduced. The folding of the wings horizontally over the body as in the Isoptera and Embioptera is in sharp contrast to the roof-like folding in other psocids but may be a secondary feature associated with their life under bark. With the loss of wings both in *Embidopsocus* and in *Liposcelis* are associated the reduction in the number of ommatidia, the loss of ocelli and the reduction of the mesothorax, but if, as appears likely, the transverse furrows on the fused meso-metanotum represent the vestiges of sutures separating these segments, then the reduction of the mesothorax has proceeded much further in *Liposcelis* than in the apterous forms of *Embidopsocus*. The relative positions of the mid coxae—near the anterior margin of the mesothorax in *Liposcelis* and more posteriorly in *Embidopsocus* would appear to be connected with this difference in the degree of reduction of the mesothorax in these two genera. Moreover, the female genitalia of *Embidopsocus* are slightly less modified than those of *Liposcelis*.

The Species of *Liposcelis*.

Introduction.

Our knowledge of the species of *Liposcelis* has increased greatly in the last ten years so that a revision of the genus, in which descriptions of both males and females are brought together for the first time, is desirable and especially so in view of a certain confusion in the identity of some of the earlier described species. In this revision twenty-two recent species are recognized. Type material and, where possible, series of specimens of eighteen of these have been examined by me. Four new species are described and the redescriptions in all cases embody material as yet unpublished. The remaining four species are probably identifiable from the original descriptions. Detailed descriptions of *liparus*, *terricolis* Badonnel (= *luridus* Broadhead), *pubescens* and *subfuscus* and redescriptions of *formicarius* and *entomophilus* have only recently been published (Broadhead, 1947*a*, *b*, *d*) and are not repeated, but remarks on their affinities with other species and some further information is presented here.

Of other specific names, several have already been recognized as synonyms, one as a *nomen nudum* and six have been founded on such an insecure basis that recognition of the species is impossible. Since type material of these latter species probably does not exist they are here listed as *incertae sedis*.

It has been found impossible to group the species taxonomically since they show a permutation of characters. There appear, however, to be several closely related pairs of species, the members of each pair being more closely allied to each other in metric as well as in other characters than they are to any of the remaining species, viz. *bostrychophilus* and *subfuscus*, *liparus* and *rufus*, *terricolis* and *exiguus*, and also the three species *formicarius*, *pubescens* and *mendax*. In one case two forms (*simulans* races A and B) are so closely allied that they have tentatively been given subspecific rank. The order of the species described below is essentially arbitrary. The closely-related species, and, where possible, species of similar ground colour are placed together. Treatment of the species on a geographical basis is impracticable owing to the wide dispersal of many species by commerce.

Notes on the Biology of *Liposcelis* Species.

The biology of the species has been little studied. A study of the life history and nutritional requirements of *L. bostrychophilus* (=*granicola*) has been given by Broadhead and Hobby (1944). The anatomy of a species under the name of "*divinatorius*" has been described by Noland (1924). Most *Liposcelis* species are bisexual. In several of these species investigated virgin females lay no eggs so that parthenogenesis does not occur, and in cultures the sexes are approximately equal in number. One species however, *L. bostrychophilus* is parthenogenetic and male-less, cultures having been maintained continuously for nine years without the appearance of a male. A similar condition may prevail in *L. pictus* since all the 194 specimens collected by Ball (1940) were females. Parthenogenesis is of widespread occurrence in the Corrodentia. In addition to those species which are facultatively parthenogenetic, it is interesting to note the genera in which one species is parthenogenetic and male-less, the other species having males and females in approximately equal numbers. In *Elipsocus* three British species, *hyalinus* (Stephens), *westwoodi* McLachlan and *mclachlani* Kimmins are closely allied. The two latter species have males, whereas the male of *hyalinus* is unknown and nymphs of this species have been reared from unfertilized eggs (Kimmins, 1941). Of the ten United States species of *Caecilius* only one, *C. manteri* Sommerman, is known to be parthenogenetic and is probably male-less (Sommerman, 1943*a*). Of the three American species of *Psyllipsocus*, *oculatus* Gurney and *yucatan* Gurney have males, but the male of *ramburii* Selys is probably entirely absent (Gurney, 1943). Sommerman (1943*b*) after laboratory culturing of the species concludes that no males occur in *Ectopsocus californicus* (Banks) in Illinois although males of this species do occur in California. It appears likely that the male is completely absent in *Pteroxanium* (= *Lepidilla*) *kelloggi* (Ribaga) and in *Pseudopsocus rostocki* Kolbe (see Pearman, 1928*b*).

The shape and structure of the male and female genitalia of *Liposcelis* species and the mating behaviour are remarkably constant within the genus. An account of these will be published at a later date.

Habitats.

The species of *Liposcelis* have been recorded from a variety of habitats—under bark, in vegetable litter, in ants' nests, in stored products, in insect collections and herbaria and in dwellings. All these habitats probably offer micro-climates with a fairly high humidity. No laboratory investigations of the temperature and humidity requirements of these animals have been published. The animals can be successfully cultured in the laboratory at 20–25° C. and 70 per cent. relative humidity with dried yeast as the food. On a few occasions when cultures have been accidentally exposed to low humidities (of about 30–40 per cent.) in the incubator, this has resulted in the death of all the specimens. The following is a summary of habitat records from the literature.

On or under bark: *bicolor*, *bostrychophilus*, *formicarius*, *hirsutus*, *pictus*, *terricolis*.

In vegetable litter: *bostrychophilus*, *fasciatus*, *meridionalis*, *rugosus*, *terricolis*.

In ants' nests: *formicarius*, *myrmecophilus*, *prenolepidis*.

In stored products (warehouses, bulk grain, silage bins etc.): *bostrychophilus*, *entomophilus*, *paetus* (most frequently recorded in stored products in Britain), *pubescens*, *simulans* race B, *subfuscus*, *terricolis*. (*L. paetus* and *subfuscus* have been recorded hitherto only from stored products.)

In insect collections and herbaria: *entomophilus*, *liparus*, *simulans* race A, *terricolis*.

In dwellings: *bostrychophilus*, *liparus*, *mendax*, *meridionalis*, *paetulus*, *pubescens*, *terricolis* (with *simulans* race A from a horticulture frame).

Geographical Distribution.

The genus has been so inadequately known taxonomically that, apart from type localities, there are few reliable records of distribution. In the following summary I have excluded records which are open to question owing to possible misidentification.

Species recorded from Britain: *bicolor*, *bostrychophilus*, *entomophilus*, *liparus*, *mendax*, *myrmecophilus*, *paetulus*, *paetus*, *pubescens*, *rufus*, *simulans* races A and B, *subfuscus*, *terricolis*.

Species occurring in the open in Britain, i.e. in so-called natural habitats: *bicolor*, *myrmecophilus*, *terricolis*.

List of species believed indigenous (recorded from natural habitats) to each of the major zoogeographic regions:

Palaearctic: *bicolor*, *bostrychophilus*, *formicarius*, *meridionalis*, *myrmecophilus*, *pictus*, *rugosus*, *terricolis*. (All from Europe, N. Africa or the Middle East.)

Nearctic: *bicolor*, *prenolepidis*.

Neotropical: none.

Ethiopian: *bostrychophilus*, *exiguus*, *hirsutus*, *transvaalensis*.

Oriental: *fasciatus*.

Australian: none.

The country of origin of the following species is doubtful or unknown:

entomophilus, *liparus*, *mendax*, *paetulus*, *paetus*, *pubescens*, *rufus*, *simulans*, *subfuscus*.

Commerce has been the most effective means of dispersal but air currents may have played some part. Glick (1939) records the capture of "*Liposcelis divinatorius*", one specimen, at 1000 feet and another single specimen of an unidentified species of *Liposcelis* at 500 ft. over Tallulah, La., U.S.A., 1926–31.

Taxonomic Characters.

Since it is probable that many more species of *Liposcelis* are yet to be discovered, as many characters of possible specific value as could be found have been studied, including metric characters, and their variability has been estimated. The material presented in the descriptions is therefore more than adequate for the identification of the known species. Many of these specific characters, such as chaetotaxies and number of ommatidia are very variable and the overlap between different species is so great that single observations may be of little value when used as a basis for the description of a species. Very few characters taken alone are absolutely diagnostic for a species. Notable instances are the length of the bristle on the epiproct in *liparus* (see Broadhead, 1947*b*, fig. 9) and the shape of the basal stem of the gonopods in *paetus* (fig. 8). Usually, however, the characters show varying degrees of overlap with those of other species. Ten of the twenty-two species have had detailed statistical treatment. As far as possible the keys have been constructed with full allowance for the known or expected variability of any particular character. The metric characters have been found particularly useful in the comparison of specimens of a single species from different regions as in the case of *terricolis* and have provided useful additional data in estimating the degree of divergence of two forms as in the case of *simulans*. The most important taxonomic characters are :

Colour.—In some species, viz. *bicolor*, *entomophilus* and *pictus*, the colour is a reliable diagnostic feature. In many other cases the colour differences between species are differences in texture and tone, difficult to describe. Long preservation in alcohol largely obliterates the natural colour of the paler species. The colour of *bostrychophilus* is indistinguishable from that of *subfuscus* and *simulans* when living specimens are compared side by side. In the description of colour reference is made to Ridgway's colour nomenclature as a standard for comparison. The freshly killed animals are illuminated by an electric light source as near as possible to the stage of the microscope and the colour chart is so placed that the image of the insect is superimposed on any particular colour of the chart.

Sculpturing.—The descriptions of sculpturing refer to the centre region of the vertex of the head and to the 3rd–6th abdominal terga, the remaining parts being less characteristic. This sculpturing consists of arched ridges or rows of tubercles enclosing smooth areas or areas bearing a number of tubercles, in various combinations. The tubercles vary in size from species to species, but the sculpturing is remarkably constant within the species. A certain degree of variation however exists in *paetus* among members of the same culture and the two specimens of *rugosus* differ appreciably in this respect. Only one species, *bicolor*, lacks this sculpturing of the vertex and abdominal terga and the sculpturing of *liparus* is so delicate that it may easily be overlooked. The photomicrographs presented here and in a previous paper (Broadhead, 1947*b*) are all of the same magnification and present the chief types within the genus. Whole mounts of animals in Berlese or de Faure's fluid are satisfactory to show the coarser types of sculpturing. For those species with indistinct tubercles such as *subfuscus* or for those with delicate sculpturing such as *simulans liparus*, *rufus* and *paetulus*, I have found the following method satisfactory: Treatment with cold 10 per cent. KOH solution for a day or two, staining with acid fuchsin acidified with glacial acetic acid, dehydration and clearing and dissection in Euparal on the microscope slide to isolate the cuticle of the head and abdominal terga. Any extraneous material which would obscure the sculpturing may then be removed.

Chaetotaxy of the pronotum.—The pronotum is divided by deep depressions into a central and two lateral lobes. On the lateral tip of each lateral lobe is a strong bristle, always truncated apically, the humeral seta. Other bristles truncated at their tips and of similar length and strength are present towards the anterior margin in some species and in all species there are small fine hairs mainly posteriorly. The number of bristles and hairs as well as the length of the humeral seta are important taxonomic characters.

Chaetotaxy of the thoracic sterna.—The thoracic sterna are membranous and smooth with no defined margins (fig. 7). The prothoracic sternum is approximately rectangular. It bears on its anterior half a number of long bristles, truncated at their tips, roughly at the level of the anterior margin of the pronotum and immediately in front of these bristles in the neck region a pair of very small fine hairs. On the posterior half of the sternum is present either a pair of such long bristles or none at all. The meso- and metathoracic sterna are fused and bear a number of long bristles in a transverse row at the level of the mid coxae and also a pair of very short fine hairs just anteriorly to this row. The number of bristles (excluding the fine hairs) on these sterna is sometimes diagnostic in spite of the relatively large amount of variation. The posterior pair on the prothoracic sternum appears to be a constant feature, present in all individuals of *bostrychophilus*, *paetus*, *prenolepidis*, *rugosus* and *subfuscus*, and is totally absent in all the remaining species.

Number of ommatidia.—These are best examined after removal of pigment by KOH solution and with the animal turned on its side. Among the other characters useful for confirmation of an identification are the various linear measurements, the shape of the basal stem of attachment of the gonopods to the 9th tergum (figs. 8 and 9), the number of annular ridges on the 3rd antennal segment and the presence or absence of intersegmental membranes on the 3rd and 4th abdominal terga (fig. 6).

An examination of all these characters is most conveniently made when the specimen is in the clearing fluid after treatment with KOH and staining. The widths of the head capsule and of the hind femur and the antennal length may then be measured. The antennal lengths given in the descriptions apply only to antennae with 15 segments since antennae with fewer segments are fairly frequent. It is usually necessary to compress the specimens under a coverslip before measurements of the bristles are made since a slight obliqueness of the bristle results in a considerable error in the reading.

All measurements recorded in this paper were made with a Beck screw micrometer eyepiece. For antennal length 1 micrometer unit = 0·0021 mm.; for widths of head capsule and of hind femur 1 micrometer unit = 0·0009 mm.; for the remaining characters 1 micrometer unit = 0·0002 mm. The term "standard deviation" is used to refer to the standard deviation (root mean square) of the items in a sample. The remarks at the end of each description apply to females except where otherwise stated.

Key to the species of *Liposcelis* Motschulsky.

Females.

1. With one pair of bristles, truncated apically, on posterior half of prothoracic sternum . . . . . . 2.
With no such bristles on posterior half of prothoracic sternum . . 6.
2. Abdomen yellow or pale yellow . . . . . . 3.
Abdomen medium or darker brown . . . . . . 4.
3. Each eye with 2–4 ommatidia (abdomen pale yellow, head noticeably darker, basal stem of attachment of gonopods to 9th tergum not bifurcate) . . . . . . *paetus* Pearman.
Each eye with 7 ommatidia (abdomen pale yellow to whitish, head somewhat darker) . . . . . . *prenolepidis* (Enderlein).
4. Each eye with 4–5 ommatidia (head maroon brown, abdomen somewhat lighter) . . . . . . *rugosus* Badonnel.
Each eye with 6–8 ommatidia . . . . . . 5.
5. Sculpturing of head dorsally and of abdominal terga: spindle-shaped areas bearing indistinct minute tubercles and separated by arched lines; humeral seta 2–3 times length of adjacent small hairs on lateral lobe of pronotum . . . . . . *subfuscus* Broadhead.
Sculpturing: Spindle-shaped areas bearing distinct minute tubercles and separated by arched rows of tubercles; humeral seta approxmately equal to and always less than twice length of adjacent small hairs on lateral lobe of pronotum . . . *bostrychophilus* Badonnel.
6. Each eye with 2 ommatidia (body very pale yellow, meso-metathoracic sternum with 9–12 long bristles anteriorly) . . . . *paetulus* sp. n.
Each eye with 5–8 ommatidia . . . . . . 7.
7. Body colour: Head and thorax dark blackish brown, abdomen yellowish brown . . . . . . *meridionalis* (Rosen).
Body colour different from above . . . . . . 8.
8. On each lateral lobe of pronotum at least 4 long bristles (including humeral seta) truncated apically, in a transverse row towards anterior margin . . . . . . 9.
On each lateral lobe of pronotum 3 such bristles or less . . . . . 10.
9. Sculpturing of abdominal terga: Elongate spindle-shaped areas separated by arched lines and with no tubercles (body dark brown) *pubescens* Broadhead.
Sculpturing of abdominal terga: Spindle-shaped areas bearing distinct tubercles and separated by rows of tubercles (body yellow ochre with transverse dark reddish brown bands on abdominal terga 3 and 4 and on each terga 6–9) . . . . . . *entomophilus* (Enderlein).
10. Each eye with 8 ommatidia . . . . . . 11.
Each eye with 4–7 ommatidia . . . . . . 15.

11. Anterior half of prothoracic sternum with 8 long bristles, truncated apically (body pale yellow ochre with the following parts pale brown —meso-metathorax and 3 transverse bands on abdomen) *fasciatus* (Enderlein).
Anterior half of prothoracic sternum with 2–7 such bristles . . . 12.

12. Body colour pale rust yellow with terminal half of abdomen dark rust yellow . . . . *transvaalensis* (Enderlein).
Body colour medium to dark brown . . . . 13.

13. Each lateral lobe of pronotum with 3 long bristles (including humeral seta) truncated apically, in a transverse row towards anterior margin (the short hairs on abdominal terga all noticeably truncated apically) *hirsutus* Badonnel.
Each lateral lobe of pronotum with less than 3 such bristles . . . 14.

14. Sculpturing of abdominal terga : Elongate spindle-shaped areas separated by arched lines and with no tubercles ; the humeral seta approximately equal in length to adjacent small hairs on lateral lobe of pronotum . . . . *formicarius* (Hagen).
Sculpturing of abdominal terga : Relatively very large tubercles, those on terga 3–6 distributed uniformly ; humeral seta at least twice the length of the adjacent small hairs on lateral lobe of pronotum *myrmecophilus* sp. n.

15. Sculpturing of abdominal terga : Spindle-shaped areas separated by arched lines (body medium to greyish brown) . . *mendax* Pearman.
Sculpturing of abdominal terga : Spindle-shaped or polygonal areas, if present, separated not by arched lines but by rows of tubercles . 16.

16. Body colour : Head and abdomen very dark brownish black, thorax pale yellow (vertex of head and abdominal terga with a polished unsculptured cuticle) . . . . *bicolor* (Banks).
Body colour different from above . . . . 17.

17. Towards base of epiproct on each side of mid-line a long fine hair pointed at its tip, longer than width of epiproct at its base ; each lateral lobe of pronotum with 2 long bristles truncated apically (body chestnut brown, tip of abdomen noticeably darker than rest of abdomen, cuticle glossy) . . . . *liparus* Broadhead.
Towards base of epiproct on each side of mid-line no such long hair, in this position a bristle truncated at its tip and always shorter than width of epiproct at its base ; each lateral lobe of pronotum with only one long bristle truncated apically, viz. the humeral seta . . 18.

18. Body colour : A striking colour pattern ; the following parts dark blackish brown : head, femora, anterior half of abdomen and 3 large irregular patches, one median, the other two lateral, on each of terga 6, 7 and 8 ; remaining parts very pale cream . . *pictus* Ball.
Body colour different from above . . . . 19.

19. Anterior half of prothoracic sternum with 2–3 long bristles truncated apically (body colour deep reddish brown) . . . . . . *rufus* sp. n.
Anterior half of prothoracic sternum with 4–7 such bristles . . . . 20.

20. Body colour uniformly medium brown (intersegmental membranes clearly visible on abdominal terga 5–7, absent on terga 2–4, so that segments 2–5 appear fused) . . . . *simulans* sp. n. 21.
Body colour different from above . . . . 22.

21. Sculpturing of abdominal terga 3–5 : Irregular quadrilateral or pentagonal areas, each bearing many very small tubercles, the areas separated by paler tracts bordered by rows of tubercles, the tubercles very much smaller than the alveoli of the short abdominal hairs (each eye with 4–6 ommatidia) . . . . *simulans* race A.

Sculpturing of abdominal terga 3–5: Very much larger tubercles arranged in ill-defined areas, the tubercles about half the size of the alveoli of the small abdominal hairs (each eye with 7 ommatidia) *simulans* race B.

22. Sculpturing of vertex of head: The spindle-shaped areas enclosed by the arched lines short and broad, of length (transversely) about twice their breadth (body colour uniformly yellow ochre) *terricolis* Badonnel.

Sculpturing of vertex of head: These spindle-shaped areas elongate (transversely) and narrow, of length five times or more their breadth (head and thorax deep brown, abdomen pale brown) *exiguus* Badonnel.

Males.

1. Posterior half of prothoracic sternum with one pair of bristles truncated apically . . . . 2.

Posterior half of prothoracic sternum with no such bristles . . . 3.

2. Each eye with 2–3 ommatidia (abdomen pale yellow, head noticeably darker) . . . . *paetus* Pearman.

Each eye with 5 ommatidia (body colour uniformly medium brown) *subfuscus* Broadhead.

3. Each eye with 2 ommatidia (body very pale yellow) . . *paetulus* sp. n.

Each eye with 4–5 ommatidia . . . . 4.

4. Each lateral lobe of pronotum with 2–4 long bristles (including humeral seta) truncated apically and arranged in a transverse row towards anterior margin . . . . 5.

Each lateral lobe of pronotum with only one such bristle, viz. humeral seta . . . . 6.

5. Sculpturing of abdominal terga: Elongate spindle-shaped areas separated by arched lines and with no tubercles; body unicolorous brown . . . . *pubescens* Broadhead.

Sculpturing of abdominal terga: Spindle-shaped areas bearing distinct tubercles and separated by arched rows of tubercles; body ochre with several conspicuous transverse dark reddish brown bands interrupted medially on abdomen . . . . *entomophilus* (Enderlein).

6. Body colour: Head and abdomen dark glossy brownish black, thorax pale yellow . . . . *bicolor* (Banks).

Body colour different from above . . . . 7.

7. Towards base of epiproct on each side of mid-line a long fine hair pointed at its tip, longer than width of epiproct at its base (body colour glossy brown) . . . . *liparus* Broadhead.

Towards base of epiproct on each side of mid-line no such long hair, in this position a bristle truncated at its tip and shorter than width of epiproct at its base . . . . 8.

8. Body colour pale yellow ochre usually with a dense concentration of red pigment granules at postero-lateral angle of meso-metanotum *terricolis* Badonnel.

Body colour medium or reddish brown 9

9. Each lateral lobe of pronotum with 0–1 small fine hair near humeral seta; anterior half of prothoracic sternum with 3–5 long bristles truncated apically; each eye with 4–5 ommatidia; body colour pale medium brown . . . . *simulans* sp. n. race A.

Each lateral lobe of pronotum with 1 small fine hair; anterior half of prothoracic sternum with 2–3 long bristles truncated apically; each eye with 5 ommatidia; body colour deep reddish brown . *rufus* sp. n.

Liposcelis bostrychophilus Badonnel (fig. 11, and Plate 1, fig. 1).

Liposcelis bostrychophilus Badonnel, 1931, *Ann. Sci. nat.* (*Zool.*), (10) **14** (2) : 250, figs. 22, 23.
Liposcelis divinatorius (Müll.) *nec* Pearman, 1931, *Ent. mon. Mag.* **67** : 95.
Liposcelis divergens Badonnel, 1943, *Faune de France*, **42** : 139, figs. 351, 354, 356.
Liposcelis granicola Broadhead and Hobby, 1944, *Ent. mon. Mag.* **80** : 47–53, figs. 1–14.

The description of this species by Broadhead and Hobby has been supplemented by Broadhead, 1947*b*, where biometric data are tabulated and additional figures given. Two further characters of this species may be noted :

> Lighter posterior transverse bands (intersegmental membranes) clearly visible both in living specimens and in stained mounts on each of abdominal terga 3–7 and on 8th tergum laterally ; basal stem of attachment of gonopods to 9th tergum bifurcate.

Distribution.—Probably an African species introduced into Europe.

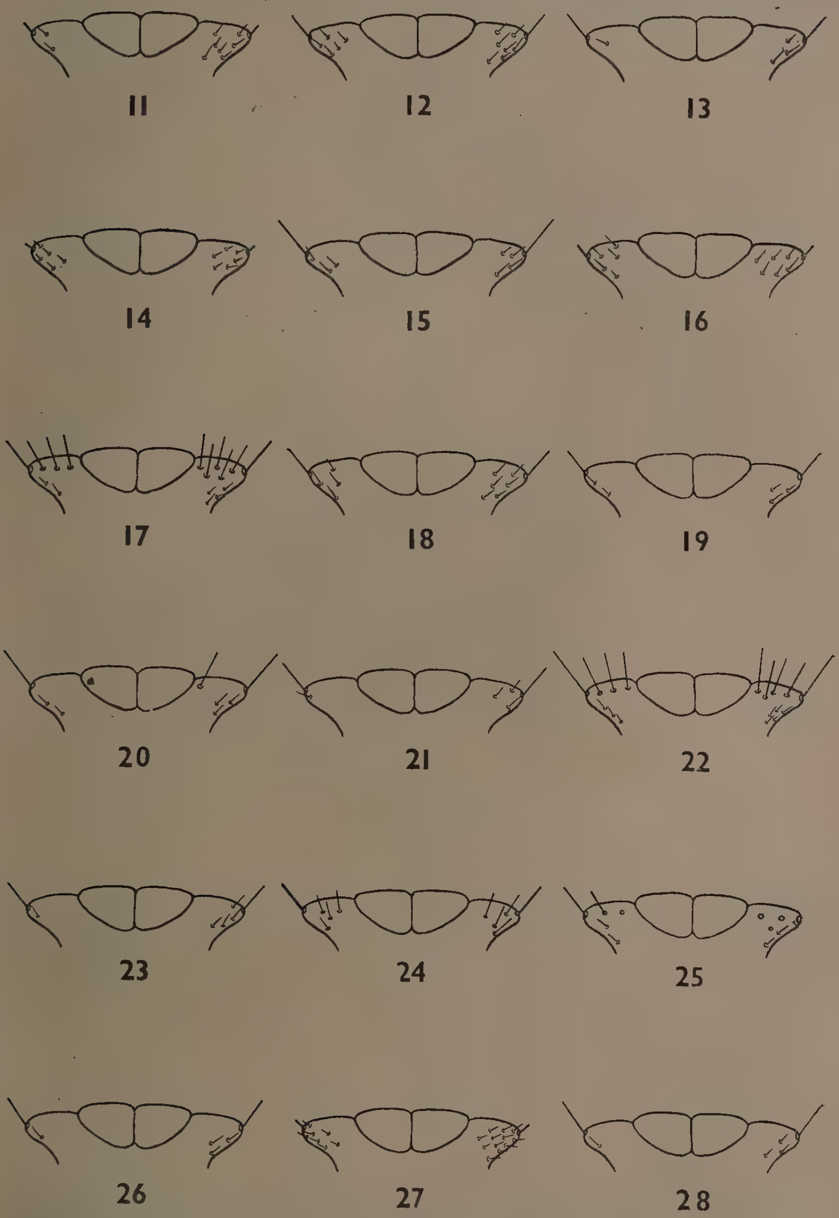
AFRICA : Mozambique, Vila-Pery, on stem of cotton plant in gallery of *Sinoxylon ruficorne* Fahr. (Col., BOSTRYCHIDAE), 9th December, 1928, type locality (Badonnel, 1931) ; Morocco, Bord du Sous near Agadir, in vegetable mould, 5th May, 1939 (Badonnel, 1945) ; Belgian Congo, Katana (Kivu), in a collection of insects from the neighbourhood of Kivu, 1931 (Badonnel, 1946) ; Belgian Congo, Eala, on an orange tree, September, 1936, N'Dele, on the branches of a species of ANONACEAE bearing colonies of a coccid (LACCIFERIDAE), 1936 (Badonnel, 1948) ; Ivory Coast, Le Banco, under bark of banana tree (Badonnel, 1949).

EUROPE : In houses in Paris (Badonnel, 1943) ; in cultures of stored product insects, Biological Field Station, Slough, Bucks, 1941 (Broadhead and Hobby, 1944) ; in cultures of *Dermestes* living on bonemeal and carrion, Bureau of Animal Population, Oxford, November, 1949.

Type specimen in the Museum national d'Histoire naturelle, Paris. Other specimens in the Hope Department of Entomology, Oxford, and in the collections of A. Badonnel and myself.

Synonymy.—The type material of *bostrychophilus*, *divergens* and *granicola* has been examined, the correspondence being extremely close. The sculpturing of the *bostrychophilus* and *granicola* specimens differs slightly however. In the latter on both head and abdomen, the tubercles bounding the spindle-shaped areas are very close together, sometimes giving the impression of continuous lines (Broadhead, 1947*b*, Plate 1, figs. 3, 8), whereas in the type specimen of *bostrychophilus* the tubercles are somewhat larger and are relatively farther apart so that the spindle-shaped areas are not so well defined (Plate 1, fig. 1). The number of small fine hairs adjacent to the humeral seta on the lateral lobe of the pronotum is 5 and 7 on the two sides in the type female of *bostrychophilus* and varies from 2–5 in 20 specimens of *granicola*. These differences appear to represent differences between distinct populations since the sculpturing of large numbers of *granicola* from laboratory cultures was extremely constant.

Remarks.—*L. bostrychophilus* is allied to *subfuscus*. They are indistinguishable in colour. Both have a pair of bristles on the posterior half of the prothoracic sternum, a character shared by only three other species in the genus, viz. *paetus* and *rugosus* and *prenolepidis*. The intersegmental membranes on abdominal terga 3–7 and the subdivisions of the 1st and 2nd terga are clearly visible in living specimens of both species. *Subfuscus*, however, is consistently



Figs. 11–28.—♀ prothorax, dorsal view to show chaetotaxy of lateral lobes (the number of hairs and bristles on left and right sides represents extreme observations): (11) *L. bostrychophilus*. (12) *L. subfuscus*. (13) *L. simulans* race A. (14) *L. rugosus*. (15) *L. mendax*. (16) *L. formicarius*. (17) *L. pubescens*. (18) *L. myrmecophilus*. (19) *L. bicolor*. (20) *L. liparus*. (21) *L. rufus*. (22) *L. entomophilus*. (23) *L. terricolis*. (24) *L. exiguus*. (25) *L. hirsutus*. (26) *L. pictus*. (27) *L. paetus*. (28) *L. paetulus*.

larger than *bostrychophilus* both in body measurements and in bristle length. In antennal length and in the lengths of humeral seta, of the longest apical abdominal bristle and of the longest bristle on the epiproct, extreme measurements do not overlap. In addition to these features the following characters are reliable for purposes of identification. The humeral seta is 2–3 times the length of the adjacent small hairs on the lateral lobe of the pronotum in *subfuscus*, whereas the humeral seta of *bostrychophilus* is usually equal in length and always less than twice the length of the adjacent hairs. The sculpturing of the two species is also quite distinct. On both the vertex of the head and the abdominal terga in *subfuscus* the arched ridges are clearly visible, but the tubercles are very indistinct, whereas in *bostrychophilus* the tubercles are distinct and these are grouped into spindle-shaped areas not by ridges, but by rows of tubercles. No males occur in *bostrychophilus*, the sexes being roughly equal in cultures of *subfuscus*. *L. simulans*, although identical in colour with the two species mentioned above, may easily be distinguished from them by the absence of intersegmental membranes on abdominal terga 3 and 4, so that terga 3-5 appear fused.

Liposcelis subfuscus Broadhead (figs. 10*b* and 12).

Liposcelis subfuscus Broadhead, 1947, *Trans. R. ent. Soc. Lond.* **98** : 48–50, fig. 5, and Plate I, fig. 7.

To the original description the following character may be added:

Female.—Basal stem of attachment of gonopods to 9th tergum bifurcate. The photograph of the sculpturing of the abdominal terga given in the original description has unfortunately been reproduced upside down.

Distribution.—The country of origin is unknown.

ENGLAND: In Orris root from Slough, Bucks, 10th September, 1943, type locality; on walls and floor of granary, Millwall, London, 16th April, 1943; in grain dust (N. Manitoba wheat) from walls and floor of Symon's Wharf, London, 18th May, 1944 (Broadhead, 1947*b*).

Type specimen in the Hope Department of Entomology, Oxford, and other specimens in my collection.

Remarks.—*L. subfuscus* is allied to *L. bostrychophilus*. The chief distinguishing features are summarized in the remarks on this latter species. The sculpturing is distinctive and readily separates it from all other species of the genus. Should the tubercles, which are always rather indistinct, be overlooked, however, the sculpturing would appear very similar to that of *L. formicarius* and *pubescens*. Both these latter species lack the pair of bristles, present in *subfuscus*, on the posterior half of the prothoracic sternum, and the chaetotaxy of the lateral lobes of the pronotum differs in *subfuscus* and *pubescens*.

Liposcelis simulans sp. n. Race A (figs. 6, 13, and Plate I, fig. 2).

Female.—*Colour* (of freshly killed individuals against a white background at magnification of 62 diameters in artificial light; colour nomenclature of Ridgway, 1912): Body semi-transparent. Upperside dull brown, thorax and abdomen Sayal Brown; cranium with light from behind a darker brown, with light from in front a yellower brown than abdomen; clypeus more reddish; eyes black; antennae almost colourless; legs as abdomen; red pigment granules on terminal segment of maxillary palpi, on 2nd antennal segment distally, scattered irregularly over head and thorax and sparsely scattered on abdominal terga 1–5 laterally. Underside: Shiny, slightly lighter than upperside; mouthparts reddish; subgenital plate somewhat darker laterally; red pigment granules sparsely scattered on head, larger granules on neck and on thoracic sterna.

Sculpturing (stained with acid fuchsin and examined at magnification of 700 diameters, Plate I, fig. 2): Cranium dorsally with distinct arched ridges enclosing transverse spindle-shaped areas, these areas smooth or bearing only very indistinct minute tubercles, the tubercles more distinct laterally near eye and antennal sclerite. Abdominal terga 3–5 with irregular quadrilateral or pentagonal areas, each bearing many very minute tubercles, the areas separated by more lightly stained tracts bordered by rows of tubercles; the areas become more elongate and spindle-shaped on 6th and 7th terga and very elongate on 8th–10th terga, the rows of tubercles bounding them being partially or completely fused to form arched ridges. Epicranial suture indicated by a break in the sculpturing.

Head: With fine hairs uniformly scattered, average length of these hairs on vertex (0·013 mm.) 1–2 times width of adjacent spindle-shaped areas on cuticle, distance between hairs (average 0·026 mm.) about twice their length. Third antennal segment with 13–17 annular ridges—in 20 specimens 4 with 13, 4 with 14, 5 with 15, 6 with 16, 1 with 17. Each eye with 5–6 ommatidia—in 50 eyes 5 with 5, 45 with 6 ommatidia (in some individuals the number of ommatidia in right and left eyes differs; one specimen from a different source had 4 and 5 ommatidia in left and right eye respectively).

Thorax: Each lateral lobe of pronotum with a long strong bristle, truncated apically, on its lateral tip ("humeral seta", Table I) and with 1–3 small fine hairs more posteriorly near humeral seta. Prothoracic sternum with 4–6 long bristles in an arched row in anterior half of sternum—in 36 specimens 14 per cent. with 4 bristles, 53 per cent. with 5, 33 per cent. with 6; no such bristles in posterior half of sternum. Meso-metathoracic sternum with transverse slightly arched row of 6–10 bristles towards anterior margin—in 36 specimens 3 per cent. with 6 bristles, 17 per cent. with 7, 52 per cent. with 8, 25 per cent. with 9, 3 per cent. with 10.

Abdomen: With short fine hairs uniformly scattered, average length of these hairs (on terga 3–7) 0·011 mm., distance between hairs 2–4 times their length; with long strong

TABLE I.—*Linear Measurements of* Liposcelis simulans *Race A*.

Female.

Character.	N.	Mean. (mm.).	Standard deviation.	Extremes.
Width of head capsule	30	0·235	0·005	0·224 ; 0·247
Antennal length	36	0·666	0·029	0·615 ; 0·742
Length of 4th antennal segment	25	0·055	0·004	0·049 ; 0·063
Greatest width of hind femur	30	0·142	0·005	0·132 ; 0·152
Length of humeral seta	30	0·033	0·002	0·030 ; 0·037
Length of longest apical abdominal bristle	30	0·075	0·003	0·069 ; 0·082
Length of longest bristle on epiproct	17	0·056	0·002	0·053 ; 0·060

Male.

Character.	N.	Mean (mm.).	Standard deviation.	Extremes.
Width of head capsule	25	0·179	0·005	0·169 ; 0·189
Antennal length	20	0·598	0·043	0·502 ; 0·670
Length of 4th antennal segment	20	0·049	0·003	0·045 ; 0·056
Greatest width of hind femur	25	0·108	0·004	0·098 ; 0·116
Length of humeral seta	20	0·026	0·001	0·023 ; 0·027
Length of longest apical abdominal bristle	24	0·071	0·004	0·063 ; 0·080
Length of longest bristle on epiproct	8	0·048	0·001	0·046 ; 0·051

bristles, truncated apically, on 8th, 9th and 10th terga laterally, on epiproct, paraprocts and subgenital plate ; 5 such bristles on each side of almost equal length and longer than remaining bristles on lateral margin of abdomen, one of these on lateral margin of 8th tergum (this bristle measured, Table I), two on lateral margin of 9th between basal horns of gonopods and two on lateral margin of 10th tergum (Table II). Towards base of epiproct on each side of mid-line a bristle, truncated apically and longer than remaining bristles on epiproct, this bristle measured (Table I). In stained preparations, 1st tergum divided into two rather indistinct transverse bands, both interrupted medially, and 2nd tergum divided into two transverse bands, the posterior band twice as broad as the anterior one (these sclerites usually very indistinct in living specimens). Terga 5–7 and 8th tergum laterally each with a lighter posterior transverse band (intersegmental membrane), no such intersegmental membranes on 3rd and 4th terga so that terga 3–5 appear fused, a more darkly staining transverse streak medially and a break in the sculpturing laterally on anterior borders of 4th and 5th terga indicate the line of division between these segments. Basal stem of attachment of gonopods to 9th tergum bifurcate.

Body length 0·96–1·14 mm. (20 measurements). Various body measurements are given in Table I.

Male.—Colour : As female, but uniformly slightly lighter ; on upperside : red pigment granules on terminal segment of maxillary palpi, on 2nd and 4th antennal segments, scattered irregularly over head and thorax and sparsely scattered on abdominal terga 1–6 laterally ; on underside : large red pigment granules irregularly scattered on head and on thoracic sterna, smaller granules uniformly scattered on 1st and 2nd abdominal sterna and laterally on 3rd and 4th.

Sculpturing : Head dorsally as female. Sculpturing of abdominal terga as female, but more delicate and proportionately smaller, the tubercles being virtually absent, so that the lightly stained tracts separating the polygonal areas are the most noticeable feature (best observed in mounts of isolated cuticle stained with acid fuchsin). Epicranial suture indicated by a break in the sculpturing.

Head : With fine hairs uniformly scattered, average length of these hairs (0·012 mm.) about twice width of adjacent spindle-shaped areas on cuticle, distance between hairs (0·027 mm.) about twice their length. Third antennal segment with 11–14 annular ridges —in 14 specimens 2 with 11, 3 with 12, 3 with 13, 6 with 14. Each eye with 4–5 ommatidia —in 40 eyes 25 with 4, 15 with 5 ommatidia (in some individuals the number of ommatidia in right and left eyes differs).

Thorax : Each lateral lobe of pronotum with a long strong bristle, truncated apically, on its lateral tip (" humeral seta", Table I) and with 0–1 small fine hair more posteriorly near humeral seta. Prothoracic sternum with 3–5 long bristles in an arched row in anterior half of sternum—in 25 specimens 48 per cent. with 3 bristles, 48 per cent. with 4, 4 per cent. with 5 ; no such bristles in posterior half of sternum. Meso-metathoracic sternum with transverse slightly arched row of 5–7 bristles towards anterior margin—in 25 specimens 28 per cent. with 5 bristles, 48 per cent. with 6, 24 per cent. with 7.

Abdomen : With short fine hairs uniformly scattered, average length of these hairs (on terga 3–7) 0·010 mm., distance between hairs 2–4 times their length ; with long strong bristles, truncated apically, on 8th, 9th and 10th terga laterally, on epiproct, paraprocts and subgenital plate ; 5 such bristles on each side of almost equal length and longer than remaining bristles on lateral margin of abdomen, one of these on lateral margin of 8th tergum (this bristle measured, TableI), two on lateral margin of 9th and two on lateral margin of 10th tergum. Towards base of epiproct on each side of mid-line a bristle, truncated apically and longer than remaining bristles on epiproct, this bristle measured (Table I). In stained preparations 1st and 2nd terga each divided into two indistinct transverse sclerites, those of 1st tergum interrupted medially (these sclerites very indistinct in living specimens). Terga 6–8 each with a broad membranous posterior transverse band (intersegmental membrane), no such intersegmental membranes on terga 2–5, so that terga 2–6 appear fused, a more darkly staining transverse streak medially and a break in the sculpturing laterally on anterior borders of 3rd–6th terga indicate the line of division between these segments.

Body length 0·72–0·84 mm. (20 measurements). Various body measurements are given in Table I.

Distribution.—The country of origin is unknown.

ENGLAND: In an old horticulture frame, Salisbury, Wiltshire, 3rd November, 1945, type locality (collected by H. G. Stokes, Esq.). Two generations reared on yeast at 25° C. and 76 per cent. R.H. with great difficulty owing to an exceptionally high infertility rate. Several individuals in an insect collection at Oxford, 27th May, 1948.

Type (♀) and paratypes (♂♂ and ♀♀) in the Hope Department of Entomology, Oxford and other specimens in my collection.

Remarks.—Female: *L. simulans* is identical in colour with *L. bostrychophilus* and only slightly smaller. *L. subfuscus* is somewhat larger and is often a slightly darker brown. When freshly killed animals are viewed with lateral illumination, the sclerites on abdominal terga 1 and 2 are barely visible in *simulans*, but are very distinct in both *bostrychophilus* and *subfuscus*. In *simulans* the 3rd, 4th and 5th abdominal terga are fused and there are no obvious transverse dark brown streaks on the anterior borders of terga 3–8, whereas in these two other species these three terga are not fused, the paler intersegmental membranes between these terga being clearly visible and the dark brown streaks on terga 3–8 are distinct. For the identification of preserved specimens the following characters are also useful. The sculpturing is distinct in all three species. The presence of a pair of bristles on the posterior half of the prothoracic sternum in *bostrychophilus* and *subfuscus* separates these two species from *simulans* in which they are absent. Various body measurements differ in the three species—although the width of the head capsule is smaller than that in either of the two other species, *L. simulans* has longer bristles, there being no overlap between extreme measurements for either length of humeral seta, length of longest apical abdominal bristle or the length of the longest bristle on the epiproct. *L. mendax* probably resembles *simulans* closely in colour, but may be distinguished by its sculpturing and by the lack of fusion of the more anterior abdominal terga. It is also a larger species with a much greater head width and longer humeral seta and apical abdominal bristles. In the presence of polygonal areas on the 3rd–6th abdominal terga, consisting of small tubercles separated by lightly stained tracts bordered by rows of tubercles, *simulans* resembles *liparus* and *rufus*. In *liparus*, however, the tubercles are smaller and the sculpturing much more delicate. In *rufus* the tubercles are slightly larger and the sculpturing somewhat coarser. *Rufus* differs, however, in colour, in its much larger head width and in the absence of any tubercles on the vertex of the head.

Male: The male of *L. simulans* is identical in colour with that of *subfuscus*. It is slightly smaller, more glossy and has relatively longer antennae. In living or freshly killed specimens under lateral illumination the following characters are diagnostic. The sclerites on the 1st and 2nd abdominal terga are very distinct in *subfuscus*, but barely visible in *simulans*. Red pigment granules present in numbers on *simulans* dorsally are almost absent in *subfuscus*. In *simulans* abdominal terga 3, 4, 5 and 6 are fused and uniform in colour, the sutures between them being represented by only very fine lines, whereas the 6th, 7th and 8th terga are each divided into two transverse bands separated by a membranous tract. In *subfuscus* none of the terga are fused and the 4th–8th terga are each divided into two transverse bands. For the examination of all these characters a magnification of at least 60 diameters is desirable with reflected light. For preserved specimens the presence of a pair of bristles in the posterior half of the prothoracic sternum in *subfuscus* and their absence in *simulans* is the most reliable diagnostic character. Allowing for their smaller size the males of *Liposcelis* species show similar characters to those of their respective females. Male *simulans* may therefore be distinguished from the unknown males of *formicarius*, *myrmecophilus* and *mendax*, as well as from the known males of *pubescens* and *subfuscus*—all being brownish-coloured species—by the sculpturing. Well-stained preparations of isolated cuticle and a magnification of at least 700 diameters are, however, required in order to see the sculpturing satisfactorily. Although the sculpturing of the abdominal terga of the females of *simulans* and *rufus* differ only slightly, that of the males differ more appreciably. In *simulans* the sculpturing of the male terga is so much smaller and more delicate than that of the female that the tubercles are virtually absent and only faint, more lightly coloured tracts separating the polygonal areas are present. In *rufus*, on the other hand, the sculpturing of the male terga is as strong and almost as large as that of the female, so that the tubercles are distinctly visible.

Liposcelis simulans sp. n. Race B (Plate I, fig. 3).

Female.—Colour : Dull brown, identical in colour to race A.

Sculpturing (stained with acid fuchsin and examined at magnification of 700 diameters, Plate I, fig. 3) : Cranium dorsally with distinct arched ridges enclosing transverse spindle-shaped areas bearing distinct minute tubercles. Abdominal terga 2–5 with large distinct tubercles arranged in ill-defined quadrilateral or pentagonal areas, the tubercles about twice as large as those on head and very much larger than those on the corresponding region in race A ; on terga 7–10 the areas become more elongate and the tubercles are somewhat smaller. Epicranial suture indicated by a break in the sculpturing.

Head : With fine hairs uniformly scattered, average length of these hairs (0·012 mm.) slightly greater than width of adjacent spindle-shaped areas on cuticle, distance between hairs (0·028 mm.) 2–3 times their length. Third antennal segment with 21 and 29 annular ridges (1 individual). Each eye with 7 ommatidia (2 individuals).

Thorax : Each lateral lobe of pronotum with a long strong bristle, truncated apically, on its lateral tip (" humeral seta", Table II) and with 3 small fine hairs more posteriorly near humeral seta (2 individuals). Prothoracic sternum with 4–5 long bristles in an arched row in anterior half of sternum ; no such bristles in posterior half. Meso-metathoracic sternum with transverse slightly arched row of 7 bristles towards anterior margin (2 individuals).

Abdomen : With short fine hairs uniformly scattered, average length of these hairs (on terga 3–7) 0·010 mm., distance between hairs about four times their length ; with long strong bristles, truncated apically, on 8th, 9th and 10th terga laterally, on epiproct, paraprocts and subgenital plate ; 5 such bristles on each side of almost equal length and longer than remaining bristles on lateral margin of abdomen (Table II), one of these on lateral margin of 8th tergum, two on lateral margin of 9th between basal horns of gonopods and two on lateral margin of 10th tergum. Towards base of epiproct on each side of mid-line a bristle, truncated apically and longer than remaining bristles on epiproct, this bristle measured (Table II). In stained preparations, terga 1 and 2 divided into sclerites as in race A ; terga 5–7 and 8th tergum laterally each with a lighter posterior transverse band (intersegmental membrane), no such intersegmental membranes on 3rd and 4th terga, so that terga 3–5 appear fused, a break in the sculpturing indicating the line of division between these segments, there being no transverse more deeply staining medial streaks on anterior borders of any tergum. Basal stem of attachment of gonopods to 9th tergum bifurcate.

Body length 1·11 mm. (one measurement). Various body measurements are given in Table II, together with corresponding data of race A for comparison (the ranges given for linear measurements of race A in this Table are the statistical extremes, i.e. mean plus and minus three times standard deviation).

TABLE II.—*Comparison of Females of Race A and Race B of* Liposcelis simulans (*linear measurements in mm.*).

Character.	Race A.	Race B.
Width of head capsule	0·220–0·250	0·249, 0·253
Length of hairs on vertex of head	0·013	0·012
Distance between hairs on vertex	0·026	0·028
Length of hairs on abdominal terga 3–7	0·011	0·010
Greatest width of hind femur	0·127–0·157	0·158
Length of humeral seta	0·027–0·039	0·032, 0·033
Length of longest bristles on lateral margin of—		
8th tergum	0·066–0·084	0·072
9th ,, more dorsally	0·069	0·077
9th ,, ,, ventrally	0·063	0·063
10th ,, ,, dorsally	0·070	0·062, 0·065
10th ,, ,, ventrally	0·066	0·057, 0·067
Length of longest bristle on epiproct	0·050–0·062	0·057
Number of ommatidia	5–6	7
Number of annular ridges on 3rd antennal segment	13–17	21, 29
Chaetotaxy of lateral lobes of pronotum	1 humeral seta, 1–3 small hairs	1 humeral seta. 3 small hairs
Number of bristles on—		
Prothoracic sternum	4–6	4, 5
Meso-metathoracic sternum	6–10	7

ENGLAND: Two ♀ in home-grown dredge corn and oats obtained from Mr. Edmonds, West Alvington, near Kingsbridge, Devon, 1946 (given to me by Dr. B. M. Hobby).

Type and paratype in the Hope Department of Entomology, Oxford.

Remarks.—Both specimens of race B are identical with those of race A in their colour, in the fusion of the 3rd, 4th and 5th abdominal terga, in the chaetotaxy of the lateral lobes of the pronotum and of the thoracic sterna. They differ in having 7 ommatidia in each eye and in having 21 and 29 annular ridges on antennal segment 3, compared with the 5–6 ommatidia and 13–17 annular ridges of race A. These differences are probably significant in view of the large number of specimens of race A examined. There is a pronounced difference, however, in the sculpturing. In race B the tubercles on the head are distinctly visible and those on abdominal terga 2–5 are extremely large, about twice the size of those on the head and very much larger than those on the corresponding region of race A. These differences cannot be ascribed to the variability of the sculpturing in a single wild population, since large numbers of race A showed no visible variation in this character. The fact that the two specimens of race B were identical in sculpturing and in the number of ommatidia is good evidence that a definite race is involved and not a highly aberrant individual or hybrid. Linear measurements of the two races are compared in Table II.

It may be noted here that all the characters of race B measured fall within the range of variation of the corresponding characters of race A. In view of this close correspondence and in the absence of any biological data the two forms are here regarded as races of a single species. The sculpturing of the abdominal terga of race B is similar to that of *myrmecophilus* and *rugosus*, the tubercles of these latter species, however, being larger.

Liposcelis rugosus Badonnel—redescription (fig. 14, and Plate I, figs. 4–7).

Liposcelis rugosus Badonnel, 1945, *Rev. franç. Ent.* **12** : **34–35**, figs. 1–4.

Female.—Colour : Upperside : cranium maroon brown ; antennae, maxillary palpi and tarsi very pale ; eyes brownish-black ; thorax and legs light brown ; abdomen as cranium, but somewhat lighter ; each abdominal tergum with a broad brown transverse band (from Badonnel, 1945).

Sculpturing (Plate I, figs. 4, 5) : Head dorsally : covered uniformly with very large tubercles, much larger than those of any other known *Liposcelis* species, diameter of tubercles 1–3 times diameter of alveoli of the small hairs on the vertex of the head, tubercles not arranged in areas and no arched ridges present. Abdominal terga 3–7 with smaller tubercles arranged uniformly, their diameter equal to that of the alveoli of the abdominal hairs. Epicranial suture indicated by a break in the sculpturing.

Head : With short fine hairs uniformly scattered, average distance between hairs (0·017 mm.) approximately four times length of hairs, length of hairs 1–2 times diameter of adjacent tubercles. Third antennal segment with 11 annular ridges. Right eye with 5, left with 4 ommatidia.

Thorax : Each lateral lobe of pronotum with a short fine hair on lateral tip (" humeral seta") not stronger or longer than the 5–6 small fine hairs adjacent to it. Prothoracic sternum : in anterior half 2 bristles, in posterior half 2 bristles. Meso-metathoracic sternum with transverse slightly arched row of 5 bristles towards anterior margin.

Abdomen : With short fine hairs uniformly scattered, average length of these hairs 0·007 mm. ; all the apical abdominal bristles very short, but two of these on each side of almost equal length are longer than the rest, both these situated on lateral margin of 10th tergum near base of paraprocts, the bristle measured being the more dorsal one of this pair. In stained preparations the following sclerotized areas on the abdominal terga are clearly visible : 1st tergum divided up into 5 areas ; 2nd tergum into two transverse bands of equal width ; 3rd, 4th and 5th terga separated by lightly stained sutures and each tergum subdivided by an unstained transverse line into two transverse bands, equally sclerotized, the posterior one being very narrow (quarter width of anterior band) ; on 6th and 7th terga the unstained transverse line broadens into a typical intersegmental membrane, the posterior sclerotized band becoming correspondingly narrow laterally and almost disappearing medially ; the remaining terga uniformly sclerotized, 8th and 9th terga fused medially, but separated by a suture laterally, 9th and 10th terga separated by only a vestigial suture laterally indicated by a break in the sculpturing. Basal stem of attachment of gonopods to 9th tergum bifurcate.

Body length 1·03 mm. Various body measurements are given in Table III.

Africa : Morocco, Bord du Sous, near Agadir, in a compost heap, 5th May, 1939, 3 ♀.

Type in the Museum national d'Histoire naturelle, Paris. Paratypes in collection of Dr. A. Badonnel.

Remarks.—The above description is based on an examination of the type specimen. Badonnel (1945) remarks on the differences between this and the two paratypes. One of these paratypes has been examined by me. Although

TABLE III.—*Female. Linear Measurements (mm.) of Seven* Liposcelis *Species.*

Character.	*rugosus.*		*mendax.*	*myrmecophilus*	*bicolor.*[1]	*exiguus.*	*hirsutus.*	*pictus.*[1]
	Type.	Paratype.	Type.	Type.		Paratype.		
Width of head capsule	0·223	0·216	0·293	0·295	0·278–0·289	0·252	0·253	0·243–0·247
Antennal length	—	—	0·784	0·852	0·729, 0·763	—	—	0·741, 0·753
Length of 4th antennal segment	0·035	—	0·075	0·077	0·053–0·056	—	—	0·056–0·068
Greatest width of hind femur	0·111	0·110	0·155	0·187	0·139–0·148	—	—	0·148, 0·165
Length of humeral seta	0·009	0·007	0·040	0·030	0·026, 0·031	0·030	0·033	0·030, 0·031
Length of longest apical abdominal bristle	0·018	0·017	0·098	0·080	0·068–0·071	0·062	0·055	0·072–0·076
Length of longest bristle on epiproct	—	0·019	—	0·068	0·052–0·062	0·054	0·060	0·053–0·060

[1] Range of 3 measurements.

slightly smaller than the type specimen, a comparison of various measurements (Table III) and of the chaetotaxy does not appear to warrant any separate specific recognition at present. In all the characters described above, except in the sculpturing, type and paratype do not differ significantly, and linear measurements of four characters are almost identical. The sculpturing of the paratype differs considerably, however, from that of the type, and may be described as follows (Plate I, figs. 6, 7) head dorsally: with transverse spindle-shaped areas enclosing distinct tubercles, the areas bounded by rows of tubercles, similar to that in *L. bostrychophilus* except tubercles larger; diameter of tubercles equal to or less than that of the alveoli of the small hairs on the vertex; the tubercles near the lateral margin of the head larger than those medially, but not as large as those of the type specimen. Abdominal terga 3–7: as head, but spindle-shaped areas more elongate. The absence of arrangement of the tubercles into spindle-shaped areas on the head and the 3rd–7th abdominal terga in the type specimen may possibly be correlated with their larger size. The fact that rather indistinct spindle-shaped areas are present in this specimen on the 8th–10th terga and on the subgenital plate, where the tubercles are smaller than those more anteriorly suggests that this is so. All these observations, then, together with the agreement shown by the two specimens in the peculiar subdivision of the 3rd, 4th and 5th abdominal terga, point to the conclusion that these specimens belong to a single species with an unusually large variability on the sculpturing.

L. rugosus approaches *L. bostrychophilus* in the presence of a pair of bristles on the posterior half of the prothoracic sternum, in the very short humeral seta and apical abdominal bristles, in the number of annular ridges on the 3rd antennal segment and in the subdivision of the 1st and 2nd abdominal terga. It differs, however, in sculpturing, in colour, in linear measurements and in the subdivision of abdominal terga 3–5, and in the number of ommatidia.

In the distinct subdivision of each of abdominal terga 3, 4 and 5 (Plate I, figs. 5, 7) and in the sculpturing of the vertex of the head *rugosus* differs from all other species of this genus. The sculpturing of the abdominal terga of *rugosus*, *myrmecophilus* and *simulans* race B is similar, but the tubercles of *myrmecophilus* are larger and coarser than those of *rugosus*, those of *simulans* race B being smaller.

Liposcelis mendax Pearman—redescription (fig. 15).

Liposcelis mendax Pearman, 1946, *Entomologist* **79** : 243–244, figs. 11–18.

Female.—Colour : Brown —probably very similar when alive, to *L. bostrychophilus*, *subfuscus* and *simulans*.

Sculpturing : Head dorsally and abdominal terga with arched ridges enclosing smooth spindle-shaped areas. Epicranial suture indicated by a break in the sculpturing.

Head : With fine hairs uniformly scattered, length of these hairs (on vertex, average 0·014 mm.) 1–2 times width of adjacent spindle-shaped areas on cuticle, distance between hairs (0·022 mm.) about twice their length. Each eye with 5 ommatidia.

Thorax : Each lateral lobe of pronotum with a long strong bristle on its lateral tip (" humeral seta", Table III) and with 3–4 small hairs more posteriorly near humeral seta ; humeral seta at least 3 times as long as these adjacent hairs. Prothoracic sternum with 6 long bristles in an arched row in anterior half of sternum ; no such bristles in posterior half. Meso-metathoracic sternum with transverse slightly arched row of 5 bristles towards anterior margin.

Abdomen : With short fine hairs uniformly scattered, average length of these hairs (on terga 3–7) 0·013 mm. ; with longer and stronger bristles, truncated apically, on 9th and 10th terga laterally, on epiproct, paraprocts and subgenital plate ; three such bristles on each side of almost equal length and longer than remaining bristles on lateral margin of abdomen, one of these on lateral margin of 9th tergum between basal horns of gonopods and two on lateral margin of 10th tergum near base of paraprocts, the bristle measured (Table III) being the more dorsal one of this latter pair. 1st and 2nd terga each divided into two transverse sclerites ; a narrow membranous transverse band (intersegmental membrane) posteriorly on each of terga 3–7 inclusive and on 8th tergum laterally ; anterior borders of terga 3–8 each with a very narrow transverse darker medial streak. Basal stem of attachment of gonopods to 9th tergum bifurcate.

Body length 1·19 mm. Various body measurements are given in Table III. The above description is based on a study of the type specimen.

ENGLAND and FRANCE : In houses in Bristol and Paris, 4 ♀ (Pearman, 1946).

Type in the British Museum (Nat. Hist.).

In his original description Pearman indicates other characters, among which the following are the most important : 4–5 bristles on the anterior half of the prothoracic sternum and 6–8 on the meso-metathoracic sternum ; 17–20 annular ridges on the 3rd antennal segment ; 5–7 ommatidia ; length of humeral seta 0·033 mm.

Remarks.—L. mendax is allied to *formicarius*. The diagnostic features separating these two species are summarized in the remarks on *formicarius*. *L. mendax* may be distinguished from *bostrychophilus* and *subfuscus* by the absence of a pair of bristles in the posterior half of the prothoracic sternum, from *pubescens* by the chaetotaxy of the lateral lobes of the pronotum, and from *simulans* and *myrmecophilus* by the sculpturing.

Liposcelis formicarius (Hagen)—(fig. 16, and Plate II, fig. 8).

Atropos formicaria Hagen, 1865, *Ent. mon. Mag.* **2** : 121 ; also 1882, *Stettin. ent. Ztg.* **43**, Taf. II, fig. 9 ; 1883, *Stettin. ent. Ztg.* **44** : 294.
Troctes silvarum Kolbe, 1888, *Ent. Nachr.* **14** : 234–236, *nec silvarum* Badonnel, 1943, *Faune Fr.* **42** : 139–140.

A further description of this species, based on a study of one of Hagen's type specimens, has been given by Broadhead, 1947*a*.

Distribution.—Europe : Prussia, near Königsberg in the nests of *Formica fuliginosa* (Hagen, 1865) ; in Lapland and on the coastal region of East Prussia, often in the nests of *Formica fuliginosa* in July, type locality (Hagen, 1883)—six of Hagen's specimens are in the Museum of Comparative Zoölogy, Harvard College ; in a nest of *Formica rufa* L. near Leipzig, 30th March, 1904 ; under bark of pine trees and fences, Berlin, October, 1899, August, 1903, and May, 1904 (Enderlein, 1905) ; Poland, under bark at Losmitza, Galicia, October, 1905, 6 ♀ (Enderlein's specimens of *silvarum* in British Museum (Nat. Hist.)) ; Italy, Florence, December, 1903 (Enderlein, 1905).

Synonymy.—It is impossible to identify *silvarum* with any certainty from Kolbe's original description and his type material is untraced. The opinion of the first reviser, Enderlein, whose material is available, has therefore been accepted. This material comprises the six females from Galicia, named by Enderlein as *silvarum* and now in the British Museum (Nat. Hist.). These are here cited as plesiotypes of *silvarum*, with one of the specimens as neotype. The differences between these and Hagen's type specimen do not appear sufficient to warrant the recognition of a separate species. *L. silvarum* therefore falls as a synonym of *formicarius*. For purposes of comparison and to provide additional data, the following characters of the specimens of *silvarum* may be noted :

Female.—Sculpturing (not very distinct in the stained preparations, perhaps owing to their long preservation, Plate II, fig. 8) : Head dorsally with arched ridges enclosing smooth spindle-shaped areas, abdominal terga as head but areas very elongate.

Head : Average length of the fine hairs on the vertex (0·011 mm.) equal to width of adjacent spindle-shaped areas on cuticle, distance between hairs 2–4 times their length. Third antennal segment with 12–14 annular ridges (5 specimens). Each eye with 8 ommatidia (4 specimens). Width of head capsule (N = 6) 0·275–0·286 mm. Antennal length (N = 3) 0·771–0·826 mm. Length of 4th antennal segment (N = 6) 0·076–0·081 mm.

Thorax : Each lateral lobe of pronotum (fig. 16) with a short bristle on its lateral tip (" humeral seta "), little longer than the 5–6 thinner hairs adjacent to it. Prothoracic sternum with 3–4 long bristles in an arched row in anterior half of sternum ; no such bristles in posterior half of sternum. Meso-metathoracic sternum with transverse row of 7–8 bristles towards anterior margin. Length of humeral seta (N = 4) 0·013–0·019 mm. Greatest width of hind femur (N = 5) 0·149–0·161 mm.

Abdomen : Average length of the fine hairs on terga 3–7, 0·007 mm., distance between these hairs 3–4 times their length. Length of longest apical abdominal bristle (the more ventral one of the longest pair on lateral margin of 10th tergum near base of paraprocts) (N = 3) 0·060–0·069 mm. The longest bristle on epiproct truncated apically and situated towards its base on each side of mid-line, length (N = 1) 0·048 mm. In stained preparations, terga 1 and 2 subdivided transversely, distinct sutures separate terga 3–7 and intersegmental membranes probably occur on each of terga 3–7 and on tergum 8 laterally. Basal stem of attachment of gonopods to 9th tergum bifurcate.

Body length 1·11–1·16 mm. (N = 4).

Remarks.—*L. formicarius* is allied to *pubescens* and *mendax*. The following notes summarize the most important similarities and differences. *L. formicarius* and *pubescens* : Very similar in colour, *pubescens* being very dark brown, *formicarius* probably very dark brown to black ; both have intersegmental membranes on abdominal terga 3 and 4 ; the sculpturing is identical except for the slightly larger size of the spindle-shaped areas in *formicarius*, probably correlated with the larger size of the head. The two species are quite distinct in the chaetotaxy of the lateral lobes of the pronotum, as well as in the length of the humeral seta, these being the most reliable diagnostic features. *Pubescens* has a row of 4–6 long bristles, truncated apically, on the lateral lobe of the pronotum together with 2–4 small fine hairs, whereas *formicarius* has a single short bristle, truncated apically, on the lateral tip of this lobe with 5–6 small fine hairs adjacent to it. *Formicarius* has a larger body size (width of head capsule and lengths of antenna and 4th antennal segment), but shorter bristles (humeral seta, hairs on abdominal terga 3–7, longest bristles on abdominal apex and on epiproct). The chaetotaxy of the thoracic sterna and the number of ommatidia are of doubtful value for identification as their variability is not known.

L. formicarius and *mendax* : In both species intersegmental membranes are present on 3rd and 4th abdominal terga and the sculpturing is very similar. These two species differ in colour, *mendax* being lighter brown, in the number of ommatidia and number of annular ridges on 3rd antennal segment and in the lengths of longest apical abdominal bristle and of the humeral seta. The latter is the most reliable diagnostic feature. The humeral seta is at least three times as long as the adjacent hairs on the lateral lobe of the pronotum in *mendax*, whereas it is only slightly longer than the adjacent hairs in *formicarius*. It may be remarked that the type of sculpturing of the abdominal terga common to the above three species (i.e. arched ridges enclosing smooth elongate areas) is found in no other species of *Liposcelis*. It is approached most closely by that of *subfuscus*, where the tubercles, always indistinct, are often not visible, especially in poorly preserved mounts.

Liposcelis pubescens Broadhead (fig. 9, 17).

Liposcelis pubescens Broadhead, 1947, *Trans. R. ent. Soc. Lond.* **98** : 46–48, fig. 5 and Plate I, fig. 6.

To the original description may be added :

Female.—Basal stem of attachment of gonopods to 9th tergum bifurcate.

Distribution.—The country of origin is unknown.

England : On dusty shelves and old paper, Biological Field Station cellar, Slough, Bucks, 10th March, 1943, type locality ; on walls, Millwall Central Granary, London, 16th April, 1943 (Broadhead, 1947*b*).

Type specimen in Hope Department of Entomology, Oxford, and other specimens in my collection.

Remarks.—*L. pubescens* is allied to *formicarius* and *mendax*. The chief differences between *pubescens and formicarius* are summarized in the remarks on the latter species. *Pubescens* and *mendax* are similar in the presence of intersegmental membranes on abdominal terga 3 and 4, in the sculpturing and probably also in colour. The chaetotaxy of the lateral lobes of the pronotum provide the most reliable diagnostic feature. *Pubescens* has a transverse row of 4–6 long bristles, truncated apically, on the lateral lobe of the pronotum, together with 2–4 shorter hairs, whereas *mendax* has only a single long bristle, the humeral seta, situated at the apex of the lateral lobe, and 3–4 small fine hairs.

The male of *pubescens* may be distinguished from the male of *subfuscus* by the absence of a pair of bristles on the posterior half of the prothoracic sternum and by the chaetotaxy of the lateral lobes of the pronotum, and from the male of *simulans* by the sculpturing and by the lack of fusion of the 3rd–6th abdominal terga.

Liposcelis myrmecophilus sp. n. (fig. 18, and Plate II, figs. 9, 10).

Female.—Colour (in gum chloral, unstained): Dark brown—probably blackish brown when alive; clypeus and mouth-parts darker and more reddish.

Sculpturing (Plate II, figs. 9, 10): Cranium dorsally with distinct arched ridges enclosing transverse spindle-shaped areas, each bearing a few relatively large tubercles although many of the areas, particularly those near mid-line, smooth. Abdominal terga with relatively large tubercles, distance between tubercles less than their diameter, those on terga 3–6 distributed uniformly, those on more posterior terga arranged in transverse lines closely spaced with few or no tubercles between them. Epicranial suture indicated by a break in the sculpturing.

Head: With fine hairs uniformly scattered, average length of hairs (0·016 mm.) 1–2 times width of adjacent spindle-shaped areas on cuticle, distance between hairs (0·024 mm.) 1–2 times their length. Each eye with 8 ommatidia.

Thorax: Each lateral lobe of pronotum with a long strong bristle, truncated apically, on its lateral tip ("humeral seta", Table III) and with 4–6 small fine hairs more posteriorly near humeral seta. Prothoracic sternum with 5 long bristles in an arched row in anterior half of sternum, no such bristles in posterior half. Meso-metathoracic sternum with transverse slightly arched row of 8 bristles towards anterior margin.

Abdomen: With short fine hairs uniformly scattered, average length of these hairs (on terga 3–7) 0·011 mm., distance between hairs 2–3 times their length; with long strong bristles, truncated apically, on 8th, 9th and 10th terga laterally, on epiproct, paraprocts and subgenital plate; 4 such bristles on each side of almost equal length and longer than remaining bristles on lateral margin of abdomen, two of these on lateral margin of 9th tergum between basal horns of gonopods and two on lateral margin of 10th tergum, the bristle measured (Table III) being the more dorsal one of this latter pair. Towards base of epiproct on each side of mid-line a bristle, truncated apically and longer than remaining bristles on epiproct, this bristle measured (Table III). Terga 1 and 2 each divided into two distinct transverse sclerites. Terga 5–7 and 8th tergum laterally each with a lighter posterior transverse band (intersegmental membrane), such a band absent on terga 3 and 4, but the sutures between the 3rd, 4th and 5th terga very distinct so that these anterior terga do not appear fused at low magnifications. Anterior borders of terga 4–7 inclusive, each with a very narrow transverse darker brown medial streak. Basal stem of attachment of gonopods to 9th tergum bifurcate.

Body length (contracted) 1·16 mm. Various body measurements are given in Table III.

Distribution.—A British species.

ENGLAND: 1 ♀ from nest of *Formica rufa*, Windsor Forest, 15th September, 1933, collected by H. St. J. K. Donisthorpe, Esq.

Type female in Brit. Mus. (Nat. Hist.).

Remarks.—*L. myrmecophilus* is similar in colour to *formicaria* and *pubescens*, but may be readily distinguished from them by the chaetotaxy of the lateral lobes of the pronotum and by the sculpturing. Although intersegmental membranes are absent on abdominal terga 3 and 4, the sutures between them are so distinct that terga 3–5 do not appear fused, differing in this respect from *simulans*. The sculpturing is very distinct in the extremely large size of the tubercles. Those on the abdominal terga are slightly larger than those on the terga of *rugosus*, but these two species differ in the sculpturing of the vertex of the head.

Liposcelis bicolor (Banks)—redescription (fig. 19).

Troctes bicolor Banks, 1900, *Ent. News* **11** : 559.
Troctes bicolor Enderlein, 1903, *Zool. Jb.* (Syst.) **18** : 361–362, figs. 17, 20.

Female.—Colour (of living specimens against a black background) : Upperside : very glossy ; head and abdomen very dark brownish-black ; thorax pale yellow ; legs and antennae as abdomen, but slightly lighter.

Sculpturing (stained with acid fuchsin and examined at magnification of 700 diameters) : Head dorsally smooth in region of vertex, but with indistinct arched ridges enclosing smooth spindle-shaped areas in region of occiput. No trace of sculpturing on abdominal terga. Epicranial suture absent.

Head : With fine hairs uniformly scattered, average length of these hairs (on vertex) 0·012 mm., average distance between them 0·041 mm. Third antennal segment with 14, 15 annular ridges (2 individuals). Each eye with 7 ommatidia.

Thorax : Each lateral lobe of pronotum with a long strong bristle on its lateral tip (" humeral seta", Table III) and with 2–3 small fine hairs more posteriorly near humeral seta. Prothoracic sternum with 3–4 long bristles in an arched row in anterior half of sternum, no such bristles in posterior half. Meso-metathoracic sternum with transverse slightly arched row of 5–7 bristles towards anterior margin.

Abdomen : With short fine hairs uniformly scattered, average length of these hairs (on terga 3–7) 0·008 mm., distance between hairs about 3 times their length ; with longer and stronger bristles, truncated apically, on 8th, 9th and 10th terga laterally, on epiproct, paraprocts and subgenital plate ; 5 such bristles on each side of almost equal length and longer than remaining bristles on lateral margin of abdomen, one of these on lateral margin of 8th tergum, two on lateral margin of 9th and two on lateral margin of 10th tergum, the bristle measured (Table III) being the more dorsal one of the pair on the lateral margin of the 9th tergum between the basal horns of the gonopods. Towards base of epiproct on each side of mid-line a bristle, truncated apically and longer than remaining bristles on epiproct, this bristle measured (Table III). Terga 1 and 2 not subdivided ; a posterior membranous transverse band (intersegmental membrane) on each of terga 5–7 and on 8th tergum laterally, but absent on 3rd and 4th, so that terga 3–5 appear fused. Anterior borders of terga 3–8 inclusive, each with a very narrow transverse dark medial streak about half as long as width of abdomen. Basal stem of attachment of gonopods to 9th tergum bifurcate.

Body length 1·17–1·27 mm. (4 measurements). Various body measurements are given in Table III.

Distribution.—A species indigenous to Europe and North America.

ENGLAND : In an old horticulture frame, Salisbury, Wiltshire, 3rd November, 1945 (collected by H. G. Stokes, Esq.).

Records from the literature :

U.S.A. : Many specimens running over dry boards at Falls Church, Virginia, June, 1899 (Banks, 1900), type locality. Two ♀ under bark of maple at Anderson near Virginia, Illinois, 17th September, 1902, collected by Professor J. G. Needham (Enderlein, 1903).

ENGLAND : Nymphs and adults under bark of an oak post in an orchard, Bristol, August and November, 1924, January and February, 1925 (Pearman, 1925).

GERMANY : On old grape vines, on vineyard props and under sycamore bark, at Neustadt in the Palatinate (Roesler, 1939).

Type material of Banks untraced.

The above description is based on a study of four females only. Two of these, in the British Museum (Nat. Hist.), represent the material, named by Enderlein, on which his description (1903) was based. I have seen, but unfortunately have been unable to examine, the males which are identical in colour, but smaller than the females.

Remarks.—*L. bicolor* resembles *liparus* in the absence of intersegmental membranes on abdominal terga 3 and 4, in the glossy polished nature of the cuticle and in the sculpturing of the vertex and of the abdominal terga, which is extremely faint and delicate in *liparus* and absent in *bicolor*. *Bicolor* differs from all other species of the genus in the striking colour pattern.

Liposcelis liparus Broadhead (fig. 20).

Liposcelis liparus Broadhead, 1947, *Trans. R. ent. Soc. Lond.* **98** : 42–44, figs. 1, 4–9, and Plate I, figs. 1, 4.

To the original description the following characters may be added :

Female.—Intersegmental membranes present on abdominal terga 5–7 and on 8th tergum laterally, but absent or very inconspicuous on terga 3 and 4 ; basal stem of attachment of gonopods to 9th tergum bifurcate.

Distribution.—The country of origin is unknown.

ENGLAND : On dusty shelves in the Hope Department of Entomology, Oxford, 17th September, 1941, type locality ; in a cellar on old paper, 25th March, 1943, and in a microscope slide box, 20th September, 1943, at the Biological Field Station, Slough, Bucks (Broadhead, 1947*b*). In a tin containing dried *Carex rostrata* heavily infected with the smut fungus *Ustilago*, Botany Department, Oxford, 14th October, 1948.

Type specimen in Hope Department of Entomology, Oxford, and other specimens in my collection.

Remarks.—*L. liparus* is allied to *rufus*. The chief differences between these two species are summarized in the remarks on *rufus*. *L. liparus* may be distinguished from all other species in the genus by the length of the longest bristle on the epiproct and by the chaetotaxy of the lateral lobes of the pronotum. In *liparus* the longest bristle on the epiproct is curved, gradually tapers to a point and is extremely long—longer than the width of the epiproct at its base. In all the remaining species this bristle is straight, truncated apically and much shorter—of a length always less than the width of the epiproct at its base. These remarks apply to both sexes. The chaetotaxy of the pronotum provides a less reliable diagnostic feature, which applies to the female only (fig. 20). In addition to the humeral seta at its apex, the lateral lobe of the pronotum carries a second bristle, truncated apically, almost as long and situated anteriorly. This bristle is usually much longer than the 2–3 hairs situated more posteriorly on the lateral lobe, but in some individuals it is only slightly longer and occasionally is absent.

Liposcelis rufus sp. n. (fig. 21 and Plate II, figs. 11, 12).

Female.—Colour (of freshly killed individuals against a white background at magnification of 62 diameters in artificial light. Colour nomenclature of Ridgway, 1912): Body semi-transparent. Upperside: reddish-brown, dull or only slightly shiny; cranium Ochraceous-Tawny; clypeus more reddish; eyes black; thorax similar to abdomen, but somewhat more ochraceous; abdominal terga 1–7 uniformly Prout's Brown; terga 8–10 darker (Mummy Brown); antennae and legs as abdomen, but appearing lighter owing to thinness and transparency. Underside: as upperside, but glossy, subgenital plate laterally and posteriorly, paraprocts and epiproct dark brown (Mummy Brown). Red pigment granules uniformly distributed over thorax and abdomen, clustered at apex of 2nd antennal segment, densely distributed over terminal segment of maxillary palpus and on underside concentrated chiefly at antero-lateral angles of meso-metathoracic sternum. The colour varies slightly in different individuals and with age, but markedly with differing backgrounds, e.g. against a black background at low magnifications, individuals appear a more or less uniformly deep reddish brown colour with little contrast between head and abdomen.

Sculpturing (Plate II, figs. 11,12) (mounts of cuticle stained with acid fuchsin and examined at magnification of 700 diameters): Cranium dorsally with distinct arched ridges enclosing smooth, elongate, spindle-shaped areas; abdominal terga 3–5 with irregular quadrilateral or pentagonal areas, each bearing many minute tubercles, the areas separated by more lightly stained tracts bordered by rows of tubercles, the areas become elongate and spindle-shaped on 6th–10th terga, where the rows of tubercles bounding them are fused to form arched ridges, the remaining tubercles within these areas being very indistinct. Coronal suture indicated by a slight break in the sculpturing, the posterior third with an internal ridge, so appearing darker; little or no trace of frontal sutures.

Head: With very few short fine hairs on vertex, average length of these hairs (0·012 mm.) about twice width of adjacent spindle-shaped areas on cuticle, distance between hairs 4–5 times their length. Third antennal segment with 12–17 annular ridges (15 specimens), the majority with 14 or 15. Each eye with 6–7 ommatidia—in 22 individuals 18 with 7 ommatidia in each eye, 4 with 7 on one side and 6 on the other.

Thorax: Each lateral lobe of pronotum with a long strong bristle on its lateral tip ("humeral seta", Table IV) and with 1–3 small fine hairs more posteriorly near humeral seta; in 2 individuals out of 14 examined, the humeral seta is duplicated on one side. Prothoracic sternum with 2–3 long bristles in an arched row in anterior half of sternum—in 25 specimens, 24 per cent. with 2 bristles, 76 per cent. with 3; no such bristles in posterior half of sternum. Meso-metathoracic sternum with transverse slightly arched row of 5–7 bristles towards anterior margin—in 25 specimens 32 per cent. with 5 bristles, 60 per cent. with 6, 8 per cent. with 7.

Abdomen: With short fine hairs uniformly scattered, average length of these hairs (on terga 3–7) 0·011 mm., distance between hairs 2–4 times their length; with longer and stronger bristles, truncated apically, on 8th, 9th and 10th terga laterally, on epiproct, paraprocts and subgenital plate; 5 such bristles on each side of almost equal length and appreciably longer than remaining bristles on lateral margin of abdomen, one of these on 8th tergum laterally, two on 9th and two on 10th tergum laterally, the bristle measured (Table IV) being the more dorsal one of the pair on the lateral margin of 9th tergum. Towards base of epiproct on each side of mid-line a bristle, truncated apically and much longer than remaining bristles on epiproct, this bristle measured (Table IV). In stained preparations 1st and 2nd terga each indistinctly divided by a transverse clear tract into two transverse equally sclerotized bands; remaining terga uniformly sclerotized except for lighter posterior transverse bands (intersegmental membranes) on each of terga 5–7 and on 8th tergum

TABLE IV.—*Linear Measurements of* Liposcelis rufus.

Female.

Character.	N.	Mean (mm.).	Standard deviation.	Extremes.
Width of head capsule	25	0·296	0·007	0·280 ; 0·310
Antennal length	25	0·778	0·040	0·695 ; 0·859
Length of 4th antennal segment	25	0·059	0·004	0·051 ; 0·066
Greatest width of hind femur	27	0·165	0·006	0·154 ; 0·176
Length of humeral seta	25	0·031	0·002	0·027 ; 0·034
Length of longest apical abdominal bristle	25	0·064	0·004	0·056 ; 0·073
Length of longest bristle on epiproct	25	0·053	0·003	0·048 ; 0·060

Male.

Character.	N.	Mean (mm.).	Standard deviation.	Extremes.
Width of head capsule	20	0·225	0·004	0·214 ; 0·235
Antennal length	25	0·644	0·026	0·571 ; 0·678
Length of 4th antennal segment	20	0·045	0·002	0·040 ; 0·049
Greatest width of hind femur	20	0·123	0·004	0·113 ; 0·132
Length of humeral seta	20	0·021	0·002	0·018 ; 0·027
Length of longest apical abdominal bristle	20	0·060	0·003	0·054 ; 0·067
Length of longest bristle on epiproct	20	0·042	0·002	0·038 ; 0·046

laterally, no such intersegmental membranes on terga 3 and 4. In living specimens neither the subdivision of terga 1 and 2 nor the intersegmental membranes are particularly noticeable. Basal stem of attachment of gonopods to 9th tergum bifurcate.

Body length 1·26–1·43 mm. (10 measurements). Various body measurements are given in Table IV.

Male.—Colour : As female, but terga 8–10 of same colour as remaining abdominal segments.

Sculpturing : As female except for the following slight difference : abdominal terga 3–5, particularly 4th tergum, with irregular pentagonal or hexagonal areas, each bearing many very minute tubercles, the areas separated by more lightly stained tracts bordered by rows of tubercles, in places, particularly on terga 3 and 5, the areas are more elongate and the rows of tubercles bounding the areas are partially or completely fused to form distinct arched ridges.

Head : With very few short fine hairs on vertex, average length of these hairs (0·009 mm.) about twice width of adjacent spindle-shaped areas on cuticle, distance between hairs 4–5 times their length. Third antennal segment with 10–15 annular ridges (15 specimens), the majority with 12 or 13. Each eye with 5 ommatidia—in 10 individuals 100 per cent. with 5 ommatidia in each eye.

Thorax : Each lateral lobe of pronotum with a long strong bristle on its lateral tip ("humeral seta", Table IV) and with one small hair more posteriorly near humeral seta (9 individuals). Prothoracic sternum with 2–3 long bristles in an arched row in anterior half of sternum—in 20 specimens 95 per cent. with 2, 5 per cent. with 3 ; no such bristles in posterior half of sternum. Meso-metathoracic sternum with transverse slightly arched row of 3–5 bristles towards anterior margin—in 20 specimens 5 per cent. with 3 bristles, 80 per cent. with 4, 15 per cent. with 5.

Abdomen : with short, fine hairs uniformly scattered, average length of these hairs (on terga 3–7) 0·009 mm., distance between hairs 2–4 times their length ; with longer and stronger bristles, truncated apically, on 8th, 9th and 10th terga laterally, on epiproct, paraprocts and subgenital plate ; 5 such bristles on each side of almost equal length and appreciably longer than remaining bristles on lateral margin of abdomen, one of these on 8th tergum laterally, two on 9th and two on 10th tergum laterally, the bristle measured (Table IV) being the more dorsal one of the pair on the lateral margin of 10th tergum. Towards base of epiproct on each side of mid-line a bristle, truncated apically and much longer than remaining bristles on epiproct, this bristle measured (Table IV). In stained preparations 1st and 2nd terga each very indistinctly divided by a transverse clear tract into two transverse equally sclerotized bands; remaining terga uniformly sclerotized except for more lightly stained transverse bands posteriorly on each of terga 5–9, neither these nor the subdivision of the 1st two terga noticeable in living specimens.

Body length 0·90–1·03 mm. (10 measurements). Various body measurements are given in Table IV. All individuals were reared at 25° C. and 70 per cent. R.H.

ENGLAND: In a sample received 27th May, 1948, no locality given.

Type (♀) and paratypes (♂♂ and ♀♀) in Hope Department of Entomology, Oxford. Other paratypes in Brit. Mus. (Nat. Hist.).

Remarks.—*L. rufus* is allied to *liparus* and *simulans* race A. *L. rufus* and *liparus*: *L. rufus* resembles *liparus* in the contrast between the brown abdomen with its much darker terminal segments and the yellower head, but is uniformly a deeper and richer tone with an orange yellow tinge throughout. At low magnifications (× 25) *rufus* is much less shiny, lacking the highly polished gloss characteristic of *liparus*. The two species resemble one another in the presence of arched ridges and the absence of tubercles on the vertex of the head and in the arrangement of the tubercles on abdominal terga 3–5 in polygonal areas. The sculpturing of *rufus* is, however, much stronger, the spindle-shaped areas on the vertex of the head are more elongate and the tubercles on the abdominal terga are larger than those of *liparus*. The species also differ in the length of the longest bristle on the epiproct and in the chaetotaxy of the lateral lobes of the pronotum (see remarks on *liparus*). The most noticeable difference in the males of the two species lies in the deeper orange tinge of *rufus*, particularly of the head and the duller texture of the cuticle as well as in the length of the longest bristle on the epiproct.

L. rufus and *simulans* race A: The chaetotaxy of the lateral lobes of the pronotum is identical in these two species and the sculpturing of abdominal terga 3–5 is very similar. There is also a fairly close correspondence in bristle length. The differences between *rufus* and *simulans* race A (of both sexes) are summarized in the remarks on the latter species.

Liposcelis entomophilus (Enderlein) (fig. 22, Plate II, fig. 13, and Plate III, fig. 14).

Troctes entomophilus Enderlein, 1907, *Stettin. ent. Ztg.* **68**: 34–36, 1 fig.
Liposcelis bakeri Pearman, 1928, *Ent. mon. Mag.* **64**: 133, figs. 1 and 2.
Liposcelis virgulatus Pearman, 1929, *Ent. mon. Mag.* **65**: 106–107, figs. 2*a* and *b*.

This species has recently been redescribed by Broadhead (1947*d*). To this description may be added the following characters:

Female.—3rd antennal segment with 14–18 annular ridges (20 specimens); intersegmental membranes present on abdominal terga 5–7 and on 8th tergum laterally, but absent on terga 3 and 4, the sutures between the anterior terga being distinct, so that these terga do not appear fused; basal stem of attachment of gonopods to 9th tergum bifurcate.

Male.—3rd antennal segment with 10–15 annular ridges (20 specimens), the majority with 11–13.

Antennal length: female, mean (N = 20) 0·737 mm., standard deviation 0·026, extremes of sample 0·682, 0·776 mm.; male, mean (N = 40) 0·631 mm., standard deviation 0·025, extremes 0·587, 0·699 mm.

Distribution.—Widespread, but the country of origin is unknown.

SOUTH AMERICA: Among dead insects received by the Stettin Museum from Colombia, 10th August, 1906 (Enderlein, 1907), type locality.

AFRICA: Mozambique, Nova-Choupanga, February, 1928 (Badonnel, 1931).

NEW HEBRIDES: Espiritu Santo, Hog Harbour, in camp, 9th March, 1927 (Pearman, 1928), ? introduced.

ENGLAND: Among West African cacao in Metropolitan Wharf, London, 4th May, 1928 (Pearman, 1929); in sample of Accra cacao, 7th October, 1930 (Pearman, 1931); in mouldy wheat heavily infested with *Calandra, Laemophloeus* and *Tribolium*, Soham, London (Broadhead, 1947*d*); in N. Manitoba wheat in a ship at Glasgow, 30th July, 1948; on surface of bulk Russian barley in warehouse, Hull, 19th January, 1949.

Enderlein's type material (two females) in British Museum (Nat. Hist.).

Remarks.—*L. entomophilus* is allied to *terricolis*. The sculpturing, the chaetotaxy of the thoracic sterna, the yellow ochre ground colour and the absence of intersegmental membranes on abdominal terga 3 and 4 are all similar in the two species. In balsam mounts of stained cuticle the tubercles on the vertex of the head are distinct in *terricolis*, but very indistinct in *entomophilus*. *L. entomophilus* differs markedly from *terricolis* in the brown transverse markings on the abdominal terga, in the chaetotaxy of the lateral lobes of the pronotum and in the greater head width and longer humeral seta. In the presence of 4–5 long bristles on each lateral lobe of the pronotum, *entomophilus* differs from all other species of the genus except *pubescens*, from which it may easily be distinguished by the colour and the sculpturing. The male of *entomophilus* may be distinguished from the males of all other species of the genus by its colour pattern and from all except male *pubescens* by the chaetotaxy of the lateral lobes of the pronotum.

Liposcelis terricolis Badonnel (fig. 23).

Liposcelis terricolis Badonnel, 1945, *Rev. franç. Ent.* **12** : 35–36, figs. 5–8.
Troctes bicolor Banks var. *decolor* Pearman, 1925, *Ent. mon. Mag.* **61** : 126.
Liposcelis divinatorius (Müller) *sec* Pearman, 1946, *Entomologist* **79** : 238–242, figs. 1–10.
Liposcelis luridus Broadhead, 1947, *Trans. R. ent. Soc. Lond.* **98** : 45–46, figs. 3, 5, and Plate I, figs. 2, 5.

A full description with biometric data is given by Broadhead (1947*b*) under the name of *L. luridus*. To this description may be added the following characters:

Female.—Intersegmental membranes present on abdominal terga 5–7 and on 8th tergum laterally, but absent on terga 3 and 4; basal stem of attachment of gonopods to 9th tergum bifurcate. *Male.*—Abdominal terga 3–5 with no intersegmental membranes.

Distribution.—A species living in the open in England, Western Europe and N. Africa, but also distributed by commerce and maintaining itself in warehouses and dwellings.

Africa: Morocco, Bord du Sous, near Agadir, in a compost heap, 5th May, 1939, type locality (Badonnel, 1945).

Europe: England—under bark of an oak post near Bristol, August and November, 1924, and January and February, 1925 (Pearman, 1925); in a collection of insects, Batley, Yorkshire, 25th December, 1943; on dusty shelves at Biological Field Station, Slough, Bucks, 14th September, 1943; in grain dust (N. Manitoba wheat) from walls and floor of Symon's Wharf, London, 18th May, 1944; in barley shavings from Sharpness, Glos., 19th September, 1944 (Broadhead, 1947*b*); on surface of bulk Russian barley in warehouse, Hull, 19th January, 1949. This species has also been taken in Paris, Montpellier, Le Vigan, Vienna and at Rabat and Agadir in Morocco by Dr. Badonnel (private communication).

Type specimens (♂ and ♀) in the Museum national d'Histoire naturelle, Paris. Other specimens in the Hope Department of Entomology, Oxford, and in the collections of Mr. J. V. Pearman and myself.

Synonymy.—A comparison of the type male and female of *terricolis* with the type series of *luridus* suggests that both belong to a single species, although they may possibly represent genetically distinct populations. The male type specimen of *terricolis* is indistinguishable from male *luridus*. In particular the correspondence in the concentrations of pigment granules on antennal segments 3–6 and on the postero-lateral angles of the meso-metathorax (*vide* Broadhead, 1947*b*, fig. 3) is noteworthy. The sculpturing, the chaetotaxy of the pronotum and of the thoracic sterna, the number of annular ridges on the 3rd antennal segment (16 in *terricolis* ♂) and the sclerotization of the abdominal terga are all identical. Moreover, linear measurements of six characters show complete agreement (Table VI). The female type specimen of *terricolis* corresponds closely to *luridus* in most characters, but differs in strength of sculpturing, slightly in thoracic chaetotaxy and appreciably in certain linear measurements. The sculpturing of *terricolis* approaches that of *luridus* very closely in the arrangement and in the size of the tubercles and of the areas. That of *terricolis*, however, is much weaker. In stained mounts of cuticle in Euparal, the sculpturing of *luridus* is very plainly visible, that of *terricolis* being indistinct, especially on the abdominal terga. The differences in chaetotaxy are as follows: The number of small hairs near the humeral seta on the lateral lobe of the pronotum 0 and 1 on the two sides in the *terricolis* specimen, 1–4 (the great majority with 2 or 3) in 20 individuals of *luridus*; on the prothoracic and meso-metathoracic sterna respectively, 3 and 6 in *terricolis*, 4–7 and 6–10 in 50 specimens of *luridus*. There is a considerable difference between *terricolis* and *luridus* females in the width of the head capsule and in the greatest width of the hind femur, but there is no significant difference in the three bristle measurements. This will be discussed below.

Remarks.—*L. terricolis* is allied to *entomophilus*, but is much more closely related to *exiguus*. The differences between these species are summarized in the remarks on *entomophilus* and *exiguus* respectively. The concentration of red pigment granules on antennal segments 3–6 and on the postero-lateral angles of the meso-metathorax is a characteristic feature of the male. They are much less marked or absent in the female.

In view of the difference in widths of the head capsule and hind femur between the types of *terricolis* and *luridus*, measurements of other specimens

TABLE V.—*Linear Measurements of* Liposcelis terricolis, *Female, Reared at 20–25° C., 76 per cent. R.H. on Yeast, Derived from Small Number of Individuals from Bulk Russian Barley in Warehouse, Hull,* 20.i.49.

Character.	N.	Mean (mm.).	Standard deviation.	Extremes.
Width of head capsule	25	0·270	0·007	0·257 ; 0·284
Antennal length	25	0·829	0·047	0·749 ; 0·933
Length of 4th antennal segment	25	0·069	0·006	0·060 ; 0·085
Greatest width of hind femur	25	0·167	0·008	0·152 ; 0·185
Length of humeral seta	25	0·031	0·002	0·027 ; 0·036
Length of longest apical abdominal bristle	25	0·066	0·002	0·062 ; 0·072
Length of longest bristle on epiproct	25	0·049	0·003	0·042 ; 0·058

TABLE VI.—Liposcelis terricolis. *Comparison of Specimens from Different Sources.*

(Measurements in mm.)

Character.	Female.					Male.	
	"*luridus*" type series.	Paris.	Pearman's specimen.	Type female *terricolis*.	Montpellier Le Vigan, Rabat, Agadir, Vienna.	Type male *terricolis*.	"*luridus*."
Width of head capsule	0·271 (20, 0·006, 0·256–0·280)	0·269 (6, —, 0·256–0·280)		0·236	0·241 (21, 0·011, 0·224–0·260)	0·184	0·197 (20, 0·005, 0·186–0·206)
Greatest width of hind femur	0·161 (30, 0·006, 0·147–0·172)	0·158 (6, —, 0·148–0·172)	0·167	0·128	0·143 (20, 0·008, 0·128–0·152)	0·116	0·114 (20, 0·005, 0·104–0·123)
Length of humeral seta	0·029 (20, 0·001, 0·026–0·031)	0·029 (5, —, 0·026–0·033)	0·034	0·028	0·024 (18, 0·003, 0·020–0·031)	0·023	0·022 (20, 0·002, 0·019–0·025)
Length of longest apical abdominal bristle	0·068 (20, 0·001, 0·066–0·071)	0·072 (3, —, 0·070–0·075)	0·081	0·067	0·067 (14, 0·004, 0·059–0·077)	0·064	0·064 (20, 0·004, 0·058–0·070)
Length of longest bristle on epiproct	0·048 (20, 0·002, 0·044–0·051)	0·048 (5, —, 0·046–0·050)	0·056	0·050	0·050 (5, —, 0·041–0·056)	0·045	0·042 (20, 0·002, 0·037–0·046)
Antennal length						0·736	0·745 (21, 0·028, 0·677–0·792)

The figures in parenthesis are : The number measured, standard deviation of the sample and extremes observed in sample respectively.

The figures for "*luridus*" are taken from Broadhead (1947*b*), those of the specimens from Paris and from Montpellier, Le Vigan, Rabat, Agadir and Vienna have been given to me by Dr. A. Badonnel.

from different sources have been made (Tables V and VI). The samples from Montpellier, Le Vigan, Rabat, Agadir and Vienna were too small for individual statistical treatment, but since all agreed with each other in having a much smaller head width and hind femur width than the series of *luridus*, they have been grouped together in Table VI. Statistical comparison of these combined data with the *terricolis* specimens from Hull (Table V), give the following results : Difference between means of head width and hind femur width highly significant ($P < 0{\cdot}01$ in both cases), of humeral seta doubtfully significant ($P = 0{\cdot}05$), of apical abdominal bristle not significant ($P > 0{\cdot}50$). The data would appear, therefore, to fall into two groups, a group with a large width of head and hind femur comprising the *luridus* type series, the specimens from Hull and Paris and Pearman's specimen, and a group with a significantly smaller head and hind femur comprising all the specimens from the more southern localities, viz. the type female of *terricolis* and the specimens from Montpellier, Le Vigan, Vienna, Rabat and Agadir.

Liposcelis exiguus Badonnel—redescription (fig. 24 and Plate III, fig. 15).

Liposcelis exiguus Badonnel, 1931, *Ann. Sci. nat.* (*Zool.*) (10) **14** (2) : 251, figs. 24 and 25.

Female.—Colour : Head and thorax deep brown, abdomen pale brown (from Badonnel, 1931).

Sculpturing (Plate III, fig. 15) : Cranium dorsally with arched ridges enclosing very elongate spindle-shaped areas bearing minute tubercles. Abdominal terga covered uniformly with distinct minute tubercles not noticeably arranged in areas.

Head : With fine hairs uniformly scattered, length of these hairs (on vertex, average 0·013 mm.) 2–3 times width of adjacent spindle-shaped areas on cuticle, distance between hairs 1–2 times their length. Each eye with 7 ommatidia.

Thorax : Each lateral lobe of pronotum with a long strong bristle on its lateral tip ("humeral seta", Table III) and with 4 small hairs, truncated apically, more posteriorly near humeral seta. Prothoracic sternum with 4 long bristles in an arched row in anterior half of sternum ; no such bristles in posterior half. Meso-metathoracic sternum with transverse slightly arched row of 8 bristles towards anterior margin.

Abdomen : Terga 3–7 uniformly beset with short but strong hairs, truncated apically, but not dilated distally, average length of these hairs 0·009 mm., distance between hairs 2–3 times their length ; with longer and stronger bristles, truncated apically, on 8th, 9th and 10th terga laterally, on epiproct, paraprocts and subgenital plate ; 3 such bristles on each side of almost equal length and longer than remaining bristles on lateral margin of abdomen, one of these on lateral margin of 9th tergum between basal horns of gonopods and two on lateral margin of 10th tergum near base of paraprocts, the bristle measured (Table III) being the more dorsal one of this latter pair. Towards base of epiproct on each side of mid-line a bristle, truncated apically, much longer than remaining bristles on epiproct, this bristle measured (Table III). 1st and 2nd terga each divided into two transverse sclerites, remaining terga uniformly sclerotized. Basal stem of attachment of gonopods to 9th tergum bifurcate.

Body length 1·07 mm. Various body measurements are given in Table III. The above description is based on a study of a single specimen (paratype), kindly lent to me by Dr. A. Badonnel.

Africa : Mozambique : Nova-Choupanga on the Zambesi, February, 1929, 1 ♀ (Badonnel, 1931).

Type in the Museum national d'Histoire naturelle, Paris.

Remarks.—L. exiguus is very closely related to *L. terricolis*. The single specimen on which the above description is based was unfortunately not complete, so that an examination of all the characters desired was not possible. The linear measurements of *exiguus* correspond very closely with those of *terricolis*, all falling within the range of variation observed in this latter species (body length, width of head capsule, length of hairs on vertex of head and on the 3rd–6th abdominal terga, lengths of humeral seta, longest apical abdominal bristle and longest bristle on epiproct). The chaetotaxy of the pronotum and of the thoracic sterna also falls within the range of variation of *L. terricolis* and the number of ommatidia is the same in the two species. They differ in the following characters. The colour of *exiguus* is given by Badonnel as "tête et corps brun sombre, abdomen brun clair," remarking that in this respect it approaches *meridionalis*, which is a distinctly bicoloured species. *L. terricolis* is, however, a uniformly dull buff. On the vertex of the head the spindle-shaped areas enclosed by the arched ridges are short and broad in *terricolis*, the majority of the areas being of a length about twice their width (*vide* Broadhead, 1947*b*, Plate I, fig. 2), whereas in *exiguus* these areas are narrow and extremely long (transversely) of a length five times or more their breadth. The sculpturing of the 3rd–6th abdominal terga is closely similar in the two species, the tubercles of *exiguus* being somewhat smaller than those of *terricolis*. Finally the two species may differ in the intersegmental membranes. In stained preparations these membranes are paler than the rest of the tergum and their sculpturing is much more delicate. They are present in *terricolis* as relatively broad posterior bands on each of terga 5–7 and on the 8th tergum laterally, but are absent on terga 3 and 4. In *exiguus* I can see no such membranes in the stained and dissected specimen. Should this be confirmed, this would provide the most reliable diagnostic character. The sculpturing of the abdominal terga is almost identical in *exiguus* and *pictus*, but these species may be readily separated by the sculpturing of the vertex of the head and by the colour.

Liposcelis hirsutus Badonnel—redescription (fig. 25 and Plate III, fig. 16).

Liposcelis hirsutus Badonnel, 1948, *Rev. Zool. Bot. afr.* 40 (4) : 270–273, figs. 7–17.

Female.—Colour : Upperside : cranium blackish brown ; antennae, maxillary palpi tibiae and tarsi very pale ; eyes black ; thorax, femora and abdomen as cranium, but much paler (from Badonnel, 1948).

Sculpturing (Plate III, fig. 16) : Head dorsally : smooth or with only very indistinct arched ridges enclosing smooth spindle-shaped areas, the ridges more distinct posterolaterally, on occiput some of these areas contain minute tubercles and are bounded by rows of such tubercles. Abdominal terga uniformly covered with extremely small but very distinct tubercles, distance between these tubercles less than diameter of alveoli of the small abdominal hairs. No trace of epicranial suture.

Head : With relatively long fine hairs uniformly scattered, average length of these hairs 0·018 mm., average distance between them 0·012 mm. Third antennal segment with 17 annular ridges (from Badonnel, 1948). Each eye with 8 ommatidia.

Thorax : With short but relatively strong hairs, truncated apically, sparsely scattered over pro- and meso-metanota. Each lateral lobe of pronotum with 3 long and strong bristles in a transverse row towards its anterior margin, the bristle on the lateral tip (" humeral seta ") measured (Table III), and 2–3 short hairs more posteriorly ; all these hairs and bristles truncated apically. Prothoracic sternum : 5 bristles in a transverse arched row in anterior half of sternum, none in posterior half. Meso-metathoracic sternum with a transverse slightly arched row of 9 bristles towards anterior margin.

Abdomen : Terga 3–7 uniformly beset with short but strong hairs, slightly dilated distally and truncated apically, average length of these hairs 0·010 mm., distance between hairs 1–2 times their length ; probably at least 5 bristles on each side at apex of abdomen much longer than the rest (judging from the size of the alveoli), one of these on 8th tergum laterally, two on 9th and two on 10th tergum laterally, only the more dorsal bristle of the pair on the lateral margin of the 10th tergum remains in the specimen examined, this one measured (Table III). Towards base of epiproct on each side of mid-line a bristle, truncated apically and longer than remaining bristles on epiproct, this bristle measured (Table III). 1st tergum partially divided by a transverse pale narrow tract into two equally sclerotized transverse bands, these bands being confluent laterally ; remaining terga uniformly sclerotized, except for indistinct lighter posterior transverse bands (intersegmental membranes) on each of terga 5–7, no such intersegmental membranes on terga 3 and 4. Basal stem of attachment of gonopods to 9th tergum bifurcate.

Body length 1·15 mm. Various body measurements are given in Table III. The above description is based on an examination of a single specimen, kindly lent to me by Dr. A. Badonnel.

AFRICA : Eala, Belgian Congo, 1 ♀ on the trunk of the leguminous *Pentaclethra macrophylla* Benth. among colonies of the scale insect *Aspidoproctus congolensis* Vayss., 19th March, 1936, type locality (Badonnel, 1948) ; Eala, 1 ♀ in the decaying wood of a Croton tree, May, 1935 (Badonnel, 1949).

Type specimen in the Musée du Congo belge, Tervuren.

Remarks.—L. hirsutus is distinct in the following characters : The truncated and somewhat dilated tips of the short abdominal hairs (approached by *L. exiguus* in which these hairs are somewhat thinner and not dilated distally) ; the pubescence of the head, the hairs on the vertex being longer than their distance apart (approached by *L. pubescens*, *entomophilus* and *paetulus*) ; the presence of three long bristles truncated apically on each lateral lobe of the pronotum (approached by *L. pubescens* and *entomophilus*), and the sculpturing of the abdominal terga (resembling *L. pictus*, the tubercles being much smaller than those of *pictus*). *L. hirsutus* may be distinguished from *exiguus* by the chaetotaxy of the pronotum and the pubescence of the head, from *entomophilus* and *pubescens* by colour and sculpturing, from *paetulus* by the number of ommatidia and from *pictus* by colour and the chaetotaxy of the pronotum.

Liposcelis pictus Ball—redescription (fig. 26, and Plate III, fig. 17).

Liposcelis pictus Ball, 1940, *Bull. Mus. Hist. nat. Belg.* **16** (20) : 1–3, 2 figs.

Female.—Colour (of alcohol-preserved specimens against a white background at magnification of 62 diameters in artificial light ; colour nomenclature of Ridgway, 1912) : A striking colour pattern. Upperside : the following parts are dark blackish brown (Liver Brown)—clypeus, cranium, femora, the posterior half of abdominal tergum 2, terga 3 and 4 and the anterior half of 5, three large irregular patches—one median, the others lateral—on each of terga 6, 7 and 8, a narrow band bordering 10th tergum behind ; the following parts are a very pale cream (Cream Color)—thorax, 1st abdominal tergum, anterior half of 2nd and terga 5–10 (except for dark brown markings). Antennae as head, but appearing lighter owing to thinness and transparency. First 3 segments of maxillary palpi, tibiae and tarsi colourless. Terminal segment of maxillary palpi very pale brown. In one specimen the blackish brown band on the anterior half of the 5th abdominal tergum is broken up into three areas as on 6th–8th terga. Underside : Head blackish brown ; thorax and abdomen pale yellowish with blackish brown irregular markings over the thoracic sterna and on the abdominal sterna laterally.

Sculpturing (Plate III, fig. 17) : Cranium dorsally with distinct minute tubercles arranged in broad spindle-shaped areas, the areas separated by rows of tubercles. Abdominal terga with distinct minute tubercles uniformly distributed on terga 1–5, arranged in rather elongate spindle-shaped areas on terga 6–10, these areas bounded by rows of tubercles. Epicranial suture indicated by a break in the sculpturing.

Head : With moderately long fine hairs sparsely scattered, average length of these hairs (0·013 mm.) approximately equal to width of adjacent spindle-shaped areas on cuticle, distance between hairs (average 0·022 mm.) 1½–3 times their length. Third antennal segment with 15, 17 and 19 annular ridges in the 3 specimens respectively. Each eye with 7 ommatidia.

Thorax : Each lateral lobe of pronotum with a long strong bristle, truncated apically at its lateral tip ("humeral seta", Table III) and 1–3 short fine hairs more posteriorly near humeral seta. Prothoracic sternum with 4–5 bristles in an arched row in anterior half of sternum, none in posterior half. Meso-metathoracic sternum with transverse slightly arched row of 6–9 bristles towards anterior margin.

Abdomen : With short fine hairs uniformly scattered, average length of these hairs 0·012 mm., distance between hairs 2–4 times their length ; with longer and stronger bristles, truncated apically, on 8th, 9th and 10th terga laterally, on epiproct, paraprocts and subgenital plate ; 5 such bristles on each side of almost equal length and longer than adjacent bristles, one of these on 8th tergum laterally, two on 9th and two on 10th tergum laterally, the bristle measured (Table III) being the single one on the lateral margin of the 8th tergum. Towards base of epiproct on each side of mid-line a bristle, truncated apically and longer than remaining bristles on epiproct, this bristle measured (Table III). In stained preparations 1st and 2nd terga each divided by a transverse clear tract into two transverse equally sclerotized bands ; remaining terga uniformly sclerotized except for lighter posterior transverse bands (intersegmental membranes) on each of terga 5–7 and on 8th tergum laterally, no such intersegmental membranes on terga 3 and 4. Basal stem of attachment of gonopods to 9th tergum bifurcate.

Body length 1·00, 1·03 mm. Various body measurements are given in Table III.

CYPRUS : Under bark of *Eucalyptus* and in crevices of bark of pines, Larnaca, 1 ♀ (type), 180 ♀ (paratypes), 19th November, 1932 (Ball, 1940).

THE LEBANON : Beyrouth, 13 ♀, 27th November and 2nd December, 1932 (Ball, 1940).

NORTH AFRICA : Rabat, Morocco, under bark, 10th October, 1945 (Badonnel, private communication).

Type and paratypes in the collection of the Musée Royale d'Histoire naturelle de Belgique.

The above description is based on a study of three females from Morocco, given to me by Dr. A. Badonnel. The description of the sternal chaetotaxy incorporates the information given in the original description.

Remarks.—*L. pictus* is readily distinguished from all other species of the genus by its striking colour pattern. The sculpturing is also distinct, but all the remaining characters are shared with several other species. The sculpturing of the abdominal terga is almost identical to that of *exiguus*. The sculpturing of the vertex of the head approaches that of *L. bostrychophilus*, but is stronger and the tubercles are larger.

Liposcelis paetus Pearman—redescription (figs. 8, 27, and Plate III, fig. 18).

Liposcelis paetus Pearman, 1942, *Ent. mon. Mag.* **78** : 289–290, figs. 1, 2.

Female.—Colour (of freshly killed individuals against a black background at magnification of 62 diameters in artificial light ; colour nomenclature of Ridgway, 1912) : Body semi-transparent. Upperside : shiny ; cranium with light from in front deep orange yellow (Sudan Brown), with light from behind deep brownish (Raw Umber) ; clypeus more reddish ; eyes black ; abdomen pale cream yellow (Chamois) ; thorax deep brownish (Raw Umber) ; legs as thorax, but appearing lighter owing to transparency ; antennae, maxillary palpi and tarsi very pale ; no red pigment granules. Underside : glossy yellow, somewhat paler than abdomen dorsally ; mouth-parts reddish ; a few red pigment granules on thoracic sterna, absent elsewhere. The contrast in colour between head and abdomen is expecially marked at low magnifications.

Sculpturing (stained with acid fuchsin and examined at magnification of 700 diameters, Plate III, fig. 18) : More variable than most other species of this genus. Cranium dorsally with arched ridges enclosing spindle-shaped areas bearing distinct minute tubercles, the tubercles larger and more pronounced laterally near eye and antennal sclerite, the arched ridges in most individuals composed of partially fused tubercles, in some these tubercles are completely fused, forming continuous ridges, in others these tubercles are separate. Abdominal terga as head but spindle-shaped areas slightly more elongate. Epicranial suture indicated by a break in the sculpturing.

Head : With fine hairs uniformly scattered, average length of these hairs on vertex (0·010 mm.) equal to width of adjacent spindle-shaped areas on cuticle, distance between hairs (0·017 mm.) about twice their length. Third antennal segment with 7–10 annular ridges (20 specimens). Each eye with 2–4 ommatidia ; in 34 eyes, 1 with 2, 27 with 3, 6 with 4 ommatidia.

Thorax : Each lateral lobe of pronotum with 8–13 short pointed hairs, the one on the lateral tip ("humeral seta", Table VII) pointed apically and equal to or only slightly longer than the adjacent hairs, occasionally one of these hairs much longer than the rest. Prothoracic sternum with 3–5 long bristles in an arched row in anterior half of sternum—in 50 specimens 48 per cent. with 3 bristles, 38 per cent. with 4, 14 per cent. with 5 ; 100 per cent. with an additional pair in posterior half of sternum. Meso-metathoracic sternum with transverse slightly arched row of 5–7 bristles towards anterior margin—in 50 specimens 46 per cent. with 5 bristles, 44 per cent. with 6, 10 per cent. with 7.

Abdomen : With short fine hairs uniformly scattered, average length of these hairs (on terga 3–7) 0·010 mm., distance between hairs 2–3 times their length ; with longer and stronger bristles, truncated apically, on 10th tergum laterally, on epiproct, paraprocts and subgenital plate ; two such bristles on each side of almost equal length and slightly longer than remaining bristles on lateral margin of abdomen, both these situated on 10th tergum laterally near base of paraprocts, the bristle measured (Table VII) being the more dorsal one of this pair. Towards base of epiproct on each side of mid-line a bristle, truncated apically and longer than remaining bristles on epiproct, this bristle measured (Table VII). 1st tergum divided into 5 distinct areas and 2nd tergum divided into 2 distinct transverse bands, both these interrupted medially. Terga 3–7 and tergum 8 laterally, each with a narrow, posterior, membranous, transverse band (intersegmental membrane). Basal stem of

TABLE VII.—*Linear Measurements of* Liposcelis paetus.

Female.

Character.	N.	Mean (mm.).	Standard deviation.	Extremes.
Width of head capsule	50	0·253	0·006	0·240 ; 0·265
Antennal length	40	0·566	0·018	0·530 ; 0·604
Length of 4th antennal segment . .	50	0·050	0·002	0·043 ; 0·053
Greatest width of hind femur . .	50	0·125	0·005	0·116 ; 0·138
Length of humeral seta . . .	25	0·013	0·001	0·010 ; 0·015
Length of longest apical abdominal bristle	50	0·023	0·001	0·021 ; 0·026
Length of longest bristle on epiproct	25	0·020	0·002	0·016 ; 0·023

Male.

Character.	N.	Mean (mm.).	Standard deviation.	Extremes.
Width of head capsule	50	0·199	0·004	0·188 ; 0·208
Antennal length	50	0·488	0·017	0·441 ; 0·538
Length of 4th antennal segment . .	50	0·043	0·003	0·036 ; 0·049
Greatest width of hind femur . .	50	0·096	0·003	0·090 ; 0·103
Length of humeral seta . . .	10	0·009	0·001	0·008 ; 0·011
Length of longest apical abdominal bristle	50	0·024	0·002	0·021 ; 0·028
Length of longest bristle on epiproct .	30	0·019	0·001	0·017 ; 0·020

gonopods not bifurcate, but elongate and gradually tapering at its point of attachment to 9th tergum.

Body length 1·11–1·27 mm. (20 measurements). Various body measurements are given in Table VII.

Male.—Colour : As female, but uniformly slightly lighter.

Sculpturing : As female.

Head : With fine hairs uniformly scattered, average length of hairs (0·007 mm.) equal to width of adjacent spindle-shaped areas on cuticle, distance between hairs (average 0·016 mm.) 2–3 times their length. Third antennal segment with 7–10 annular ridges (10 specimens). Each eye with 2–3 ommatidia—in 34 eyes, 1 with 2, 33 with 3 ommatidia.

Thorax : Each lateral lobe of pronotum with 2-8 short pointed hairs, the one on the lateral tip ("humeral seta", Table VII) pointed apically and equal to or only slightly longer than adjacent hairs, occasionally one of these hairs much longer than the rest. Prothoracic sternum with 1–4 long bristles in an arched row in anterior half of sternum—in 50 specimens 2 per cent. with 1 bristle, 20 per cent. with 2, 72 per cent. with 3, 6 per cent. with 4 ; 100 per cent. with an additional pair in posterior half of sternum. Meso-metathoracic sternum with transverse slightly arched row of 4–6 bristles towards anterior margin ; in 50 specimens 6 per cent. with 4, 84 per cent. with 5, 10 per cent. with 6.

Abdomen : With short fine hairs uniformly scattered, average length of these hairs (on terga 3–7) 0·007 mm., distance between hairs 2–4 times their length ; with longer and stronger bristles, truncated apically, on 10th tergum laterally, on epiproct, paraprocts and subgenital plate ; two such bristles on each side of almost equal length and slightly longer than remaining bristles on lateral margin of abdomen, both these situated on 10th tergum laterally near base of paraprocts, the bristle measured (Table VII) being the more dorsal one of this pair. Towards base of epiproct on each side of mid-line a bristle, truncated apically and longer than remaining bristles on epiproct, this bristle measured (Table VII). 1st tergum divided into 5 distinct areas and 2nd tergum divided into 2 distinct transverse bands, both these interrupted medially. Terga 3–7 and 8th tergum laterally each with a narrow posterior membranous transverse band (intersegmental membrane).

Body length 0·89–0·98 mm. (20 measurements). Various body measurements are given in Table VII. All individuals of this species measured were reared on yeast at 25° C. and 76 per cent. R.H.

Distribution.—A cosmopolitan species spread by commerce ; country of origin unknown.

INDIA : In linseed oil cake dust, Calcutta, 30th July, 1937 (Pearman, 1942).

ENGLAND : In wheat, barley, maize in granaries at many English ports, 1940–1942 (Pearman, 1942). In South American wheat, Biological Field Station, Slough, Bucks, 24th February, 1943. In Plate maize in a ship at Leith, 7th March, 1945 (collected by H. E. Hinton, Esq.). In large numbers, very local in heating grain, Russian barley in a silo, December, 1948, and in large numbers in "hot spots" in Australian bulk wheat in a ship at Belfast, April, 1948.

Type material in the collection of Mr. J. V. Pearman.

This is the species most frequently represented in samples of *Liposcelis* from warehouses and ships' holds. It is found in food grains from many parts of the world—North and South America, Australia, Russia, etc., so that it has clearly become widely distributed by commerce and has perhaps established a permanent niche for itself in warehouses in many ports. The fact that the largest numbers are often found in heating grain where the temperature may rise above 100° F. suggests that this species has a tropical rather than a temperate origin.

The contrast in colour between the deep brown head and the pale yellowish abdomen is a noticeable feature of *L. paetus*. In a sample derived from Russian barley in silo bins, a relatively small number of unicolorous pale yellow females were present. From six such females only a single offspring was produced, this being the normal bicolorous type, the remaining eggs collapsing soon after being laid. From this sample the unicolorous females and some of the most noticeably bicolorous females were segregated and the width of the head capsule of all females in the culture was measured. These are as follows: The whole culture: mean 0·249 mm., standard deviation 0·011, extremes 0·229–0·277 (N = 114); unicolorous specimens, mean 0·266 mm., extremes 0·253–0·277 mm. (N = 15); sample of bicolorous specimens, mean 0·244 mm., extremes 0·229–0·264 mm. (N = 32). It is evident that the pale yellow colour of the head is correlated witn a relatively large head width, although specimens intermediate in both these characters exist.

Remarks.—*L. paetus* differs from all other species of the genus in the elongate and tapering basal stem of the female gonopods. In all the remaining species this basal sclerite broadens out considerably at its junction with the 9th tergum, giving the impression of a bifurcate end. One of these arms has been considerably reduced in *paetus*, traces of it being still visible in some specimens, and the other arm is greatly elongated. *L. paetus* also differs from all other species except *bostrychophilus*, *subfuscus*, *rugosus* and *prenolepidis* in the presence of a pair of bristles on the posterior half of the prothoracic sternum. It may be distinguished from the first two of these species by the colour and from *rugosus* by the sculpturing. The large number of short hairs (7–12) near the humeral seta on each lateral lobe of the pronotum is a distinctive feature. The male of *paetus* differs from the males of all other species except *paetulus* in the presence of only three or occasionally of only two ommatidia, the male *paetulus* having two, and from all other species except *subfuscus* in the presence of a pair of bristles on the posterior half of the prothoracic sternum.

Liposcelis paetulus sp. n. (fig. 28, and Plate III, fig. 19).

Female.—*Colour* (of freshly killed individuals against a white background at magnification of 62 diameters in artificial light; colour nomenclature of Ridgway, 1912): Body semi-transparent. Upperside: Shiny, very pale yellow; cranium with light from in front, pale orange yellow (Warm Buff), with light from behind, brownish; clypeus more reddish; eyes black; thorax and abdomen very pale yellow (Light Buff); legs as abdomen; antennae, maxillary palpi and tarsi almost colourless. Underside: Glossy, very pale yellow, somewhat paler than abdomen dorsally; mouth-parts reddish. Red pigment granules completely absent. At lower magnifications no marked contrast in colour between head and abdomen is evident.

Sculpturing (Plate III, fig. 19) (stained with acid fuchsin and examined at magnification of 700 diameters): Cranium dorsally with distinct arched ridges enclosing spindle-shaped areas, these areas smooth or bearing only very indistinct minute tubercles. Abdominal terga with distinct arched ridges enclosing very elongate spindle-shaped areas bearing distinct minute tubercles, the ridges near lateral margin and sporadically in the middle region of the tergum replaced by rows of tubercles or by rows of partially fused tubercles. No trace of epicranial suture visible.

Head: With moderately long fine hairs uniformly scattered, average length of these hairs (0·013 mm.) twice width of adjacent spindle-shaped areas on the cuticle, distance between hairs (0·012 mm.) equal to or slightly less than their length. Third antennal segment with 10–15 annular ridges (10 specimens). Each eye with 2 ommatidia—in 30 eyes 100 per cent. with 2 ommatidia.

Thorax : Each lateral lobe of pronotum with a long strong bristle on its lateral tip (" humeral seta", Table VIII) and with 1–3 small fine hairs more posteriorly near humeral seta. Prothoracic sternum with 3–6 long bristles in an arched row in anterior half of sternum—in 50 specimens 4 per cent. with 3 bristles, 72 per cent. with 4, 22 per cent. with 5, 2 per cent. with 6 ; no such bristles in posterior half of sternum. Meso-metathoracic sternum with transverse slightly arched row of 9–12 bristles towards anterior margin—in 50 specimens 24 per cent. with 9 bristles, 42 per cent. with 10, 26 per cent with 11, 8 per cent. with 12.

TABLE VIII.—*Linear Measurements of* Liposcelis paetulus.

Female.

Character.	N.	Mean (mm.).	Standard deviation.	Extremes.
Width of head capsule	25	0·235	0·003	0·229 ; 0·240
Antennal length	43	0·613	0·019	0·572 ; 0·648
Length of 4th antennal segment	25	0·056	0·001	0·053 ; 0·059
Greatest width of hind femur	25	0·136	0·004	0·125 ; 0·144
Length of humeral seta	25	0·036	0·002	0·033 ; 0·039
Length of longest apical abdominal bristle	25	0·054	0·002	0·049 ; 0·056
Length of longest bristle on epiproct	25	0·044	0·002	0·040 ; 0·047

Male.

Character.	N.	Mean (mm.).	Standard deviation.	Extremes.
Width of head capsule	25	0·175	0·003	0·169 ; 0·180
Antennal length	25	0·548	0·012	0·530 ; 0·570
Length of 4th antennal segment	25	0·047	0·002	0·044 ; 0·051
Greatest width of hind femur	25	0·099	0·003	0·094 ; 0·106
Length of humeral seta	25	0·027	0·001	0·025 ; 0·029
Length of longest apical abdominal bristle	25	0·047	0·001	0·045 ; 0·049
Length of longest bristle on epiproct	25	0·036	0·002	0·032 ; 0·039

Abdomen : With short fine hairs uniformly scattered, average length of these hairs (on terga 3–7) 0·012 mm., distance between hairs 1–2 times their length ; with longer and stronger bristles, truncated apically, on 9th and 10th terga laterally, on epiproct, paraprocts and subgenital plate ; two such bristles on each side of almost equal length and much longer than adjacent bristles, both on 10th tergum laterally near base of paraprocts, the bristle measured (Table VIII) being the more ventral one of this pair. Towards base of epiproct on each side of mid-line a bristle, truncated apically and longer than remaining bristles on epiproct, this bristle measured (Table VIII). Terga 1 and 2 not subdivided, uniformly but lightly sclerotized ; terga 3–7 and tergum 8 laterally each with a lighter posterior transverse band (intersegmental membrane). Basal stem of attachment of gonopods to 9th tergum bluntly bifurcate.

Body length 0·88–1·02 mm. (20 measurements). Various body measurements are given in Table VIII.

Male.—Colour : As female, but uniformly slightly lighter.

Sculpturing : As female (as the sculpturing is proportionately smaller than that of the female, the tubercles are exceedingly small, the sculpturing being clearly visible only in well-stained specimens at high magnifications).

Head : With fine hairs uniformly scattered, average length of these hairs (0·012 mm.)

2–3 times width of adjacent spindle-shaped areas on cuticle, distance between hairs (average 0·013 mm.) equal to or slightly greater than their length. Third antennal segment with 10–12 annular ridges (10 specimens). Each eye with 2 ommatidia—in 44 eyes 100 per cent. with 2 ommatidia.

Thorax : Each lateral lobe of pronotum with a long strong bristle on its lateral tip ("humeral seta", Table VIII) and with 1–2 small fine hairs more posteriorly near humeral seta. Prothoracic sternum with 3–4 long bristles in an arched row in anterior half of sternum—in 25 specimens 84 per cent. with 3 bristles, 16 per cent. with 4 ; no such bristles in posterior half of sternum. Meso-metathoracic sternum with transverse slightly arched row of 6–9 bristles towards anterior margin—in 25 specimens 4 per cent. with 6 bristles, 60 per cent. with 7, 32 per cent. with 8, 4 per cent. with 9.

Abdomen : With short fine hairs uniformly scattered, average length of these hairs (on terga 3–7) 0·010 mm., distance between hairs equal to or slightly greater than their length ; with longer and stronger bristles, truncated apically, on 9th and 10th terga laterally, on epiproct, paraprocts and subgenital plate ; two such bristles on each side of almost equal length and much longer than adjacent bristles, both on 10th tergum laterally near base of paraprocts, the bristle measured (Table VIII) being the more ventral one of this pair. Towards base of epiproct on each side of mid-line a bristle, truncated apically and longer than remaining bristles on epiproct, this bristle measured (Table VIII). Terga 1 and 2 not subdivided, uniformly but lightly sclerotized.

Body length 0·66–0·71 mm. (20 measurements). Various body measurements are given in Table VIII, all individuals derived from cultures maintained at 25° C. and 70 per cent. R.H.

England : 1 ♀ from cellar in University Museum, Oxford, 13th September, 1945 (collected by Miss R. M. Lodge).

Type (♀) and paratypes (♂♂ and ♀♀) in Hope Department of Entomology, Oxford. Other paratypes in Brit. Mus. (Nat. Hist.).

Remarks.—*L. paetulus* differs from all other species of the genus except *paetus* in the presence of only two ommatidia in each eye in both male and female, *paetus* having 2–4 ommatidia in the female and 2–3 in the male. Although living specimens of *paetulus* and *paetus* are superficially similar the differences between the two species are extensive. The contrast between the darker head and the pale yellow abdomen is very noticeable in most specimens of *paetus*, but much less marked in the paler coloured *paetulus*. *L. paetulus* is smaller than *paetus* in body length and head width, but has longer bristles. There is no overlap between extreme measurements of the two species for the length of the humeral seta and the lengths of the longest apical abdominal bristle and of the longest bristle on the epiproct. *L. paetus* possesses and *paetulus* lacks a pair of bristles on the posterior half of the prothoracic sternum in both sexes and the two species also differ in the chaetotaxy of the pronotum.

Other Species.

In addition to the above-mentioned species, ten others have been given inadequate descriptions in the literature. Four of these, viz. *fasciatus*, *transvaalensis*, *prenolepidis* and *meridionalis*, are probably distinct, the characters of specific value, abstracted from the original descriptions, being given in the following notes. The descriptions of the remaining six are so inadequate that their identity remains uncertain. These are listed below as *incertae sedis*. Two fossil species have also been described : *L. resinatus* (Hagen, 1882) in copal probably from Zanzibar, figured by Hagen, 1882, *Stettin. ent. Ztg.* **43**, Taf. II, fig. V, and described by him in 1883, *Stettin. ent. Ztg.* **44** : 295–296 ; and *L. atavus* Enderlein 1911 in East Prussian amber. Both are known from single specimens which are in the Berlin Palaeontological Museum.

Liposcelis fasciatus (Enderlein).

Troctes fasciatus Enderlein, 1908, *Zool. Anz.* **33** : 778–779, fig. 3.

Female : Body colour pale ochre-yellow, meso-metanotum and the following parts of the upperside of the abdomen pale brown—the 3rd tergum posteriorly and the 4th and the 7th and 8th terga, the two latter with a paler narrow posterior margin. The whole animal thus appears marked with four transverse bands, the two posterior bands often less distinct. Each eye with 8 ommatidia. Prothoracic sternum with 8 bristles in anterior half, none in posterior half. Meso-metathoracic sternum with a transverse row of 8 bristles anteriorly. Body length 1·05–1·1 mm.

South Formosa : Takao, 1 ♀ shaken from dried grass 3rd February, 1907, 2 ♀ 19th March, 1907, and 3 ♀ 17th April, 1907, shaken from bundles of reeds.

I have not been able to examine the type specimens which Enderlein states are deposited in the Stettin Zoological Museum. This species appears to be similar to *entomophilus* and *terricolis* in ground colour, but is smaller and also differs in the sternal chaetotaxy and in the number of ommatidia. The transverse markings on the abdomen are distinctive and it also possesses a larger number of bristles on the prothoracic sternum than any other *Liposcelis* species.

Liposcelis transvaalensis (Enderlein).

Troctes transvaalensis Enderlein, 1909, *Stettin. ent. Ztg.* **70** : 272, fig. 3.

Female : Body colour pale rust yellow, terminal half of abdomen dark rust yellow. Each eye with 8 ommatidia. Prothoracic sternum with 6 bristles in anterior half, none in posterior half. Meso-metathoracic sternum with a transverse row of 10 bristles anteriorly. Body length 1·3 mm.

South Africa : 1 ♀ among insects collected in the Transvaal at Zoutpansberg.

I have not been able to examine the type specimen which is stated by Enderlein to be in the Stettin Zoological Museum. This species agrees with *L. terricolis* in body length and sternal chaetotaxy, but differs in the number of ommatidia. The colour, particularly the contrast between the darker posterior half of the abdomen and the rest of the body, is distinctive. The number of bristles on the meso-metathoracic sternum is greater than that recorded for any other species of *Liposcelis* except *simulans* race A, *entomophilus*, *terricolis* and *paetulus*.

Liposcelis prenolepidis (Enderlein).

Troctes prenolepidis Enderlein, 1909, *Boll. Lab. Zool. Portici* **3** : 338, fig. 4.

Female : Head very pale rust yellow, rest of body very pale, whitish. Each eye with 7 ommatidia. Prothoracic sternum with 3 bristles in anterior half, 2 in posterior half. Meso-metathoracic sternum with a transverse row of 6 bristles anteriorly. Body length 0·95 mm.

America : California, 4 ♀ in nest of ant *Prenolepis imparis* Say.

I have been unable to trace the type material. This species is similar in both size and colour to *L. paetulus*, from which it differs in the sternal chaetotaxy and in the number of ommatidia.

Liposcelis meridionalis (Rosen).

Troctes meridionalis Rosen, 1911, *Mitt. münchen. ent. Ges.* **1911** (1, 2) : 9–10, figs. 2–6.

Head and thorax blackish brown, abdomen yellowish brown. Each eye with 7 ommatidia. Prothoracic sternum with 5 bristles in anterior half, none in posterior half. Meso-metathoracic sternum with transverse row of 8 bristles anteriorly. Maxillary pick with the 3 tines strongly diverging, their tips lying, as seen from below, almost in a straight line. The longest bristle on the epiproct truncated apically. Body length 0·87–0·98 mm. Width of head capsule 0·203–0·205 mm. Greatest width of hind femur 0·12–0·13 mm.

EUROPE : In numbers at Villefranche in dry leaves, December, 1909, and September, 1910, and at Rome in a house among dead *Leucotermes lucifugus* Rossi, October.

I have been unable to trace the type material. Rosen gives no indication of the sex of his specimens. The presence of 7 ommatidia indicates that they are probably females, in which case this species is the smallest *Liposcelis* species yet known. The body length is similar to that of female *paetulus*, but the width of the head capsule is very much less, being, in fact, comparable to the head width of the males of many other species. Rosen compares *meridionalis* with "*divinatorius*," but nevertheless makes no remark on the unusually small size of the species. *L. meridionalis* may be distinguished from all other species except perhaps *paetus* and *exiguus* by the dark head and paler abdomen. It differs from *paetus* in the number of ommatidia and in the chaetotaxy of the thoracic sterna and from *exiguus* in the width of the head capsule.

INCERTAE SEDIS.

It is impossible to identify the following *Liposcelis* species from the original descriptions with any degree of certainty. I have been unable to trace the type material.

Liposcelis brunneus Motschulsky, 1853, *Études entomologiques* **1** : 19. Gurney (1939) has reviewed the early literature on *Liposcelis* species and concludes that *L. museorum* Motsch. (*op. cit.* : **20**) is a *nomen nudum*, that *L. brunneus* is the genotype of *Liposcelis*, is of uncertain identity, but that it is congeneric with *divinatorius*.

Termes divinatorium Müller, 1776, *Zool. Dan. prod.* : 184. The numerous references to "*divinatorius*" in the literature probably refer to a number of different species.

Troctes purpurea Aaron, 1883, *Trans. Amer. ent. Soc.* **11** : 37, Plate 9, fig. 1. The type material of this species is no longer in existence.

Troctes niger Banks, 1900, *Ent. News*, **11** : 560.

Troctes corrodens Heymons, 1909, *Dtsch. ent. Z.* **1909** : 452, 3 figs. A specie evidently related to *mendax* and *subfuscus*.

Liposcelis priesneri Enderlein, 1925, *Konowia* **4** : 107. A bicoloured species with dark brown head and thorax and pale chitin yellow abdomen, similar in colour to *L. meridionalis*.

LIST OF SPECIES OF *Liposcelis* WITH SYNONYMS.

atavus Enderlein, 1911 (fossil).
bicolor (Banks, 1900).
bostrychophilus Badonnel, 1931.
  syn. *divergens* Badonnel, 1943.
  „ *granicola* Broadhead and Hobby, 1944.
entomophilus (Enderlein, 1907).
  syn. *bakeri* Pearman, 1928.
  „ *virgulatus* Pearman, 1929.
exiguus Badonnel, 1931.
fasciatus (Enderlein, 1908).
formicarius (Hagen, 1865).
  syn. *silvarum* (Kolbe, 1888).
hirsutus Badonnel, 1948.
liparus Broadhead, 1947.
mendax Pearman, 1946.
meridionalis (Rosen, 1911).
myrmecophilus sp. n.
paetulus sp. n.
paetus Pearman, 1942.
pictus Ball, 1940.
prenolepidis (Enderlein, 1909).
pubescens Broadhead, 1947.
resinatus (Hagen, 1882) (fossil).
rufus sp. n.
rugosus Badonnel, 1945.
simulans sp. n.
subfuscus Broadhead, 1947.
terricolis Badonnel, 1945.
  syn. *luridus* Broadhead, 1947.
transvaalensis (Enderlein, 1909).

THE VARIABILITY OF TEN *Liposcelis* SPECIES.

The coefficients of variability $\left(V = \frac{100\sigma}{M}\right)$ for seven characters of ten *Liposcelis* species are presented in Tables IX*a* and *b*, together with estimates of the standard errors of these coefficients $\left(\frac{V}{\sqrt{2N}}\right)$ and the number of specimens measured. These have been calculated from the data given above (Tables I, IV, VII and VIII) and from those given by Broadhead (1947*b*, Tables I and II; 1947*d*, Tables I and II). One of these species, *bostrychophilus*, is parthenogenetic, the male being entirely absent. The remaining nine species are bisexual. Males and females are present in approximately equal numbers in cultures and experiments with seven of these species indicate that parthenogenesis does not occur.

The measurements of all the species were carried out on samples taken from laboratory cultures maintained at 25° C. and 76 per cent. R.H. with yeast as the food. The cultures of each species were derived originally from only a small number of females from a single locality, those of *subfuscus*, *pubescens* and *paetulus* being derived from only a single wild caught female. For all the species except *simulans* many generations had been reared before samples were taken for measurement. The variability of the cultures of the bisexual species will presumably be relatively low owing to inbreeding and the cultures of the parthenogenetic species may be expected to be particularly homogeneous genetically. Comparison with a naturally occurring wild population is not available, however.

The coefficients have been analysed to investigate firstly, whether the parthenogenetic species differs from the bisexual species in variability, and secondly whether there is any difference in the variability of the two sexes. Significance tests at a 10 per cent. probability level have been made: the ratio of the larger to the smaller coefficient greater than the square root of the critical value given in the 5 per cent. Variance Ratio table has been regarded as significant. As a check on this at the 10 per cent. level a second method has been used: the

TABLE IX.—*Coefficients of Variability of Ten* Liposcelis *Species.*

(*a*) Females.

Species.	Width of head capsule.	Antennal length.	Length of 4th antennal segment.	Greatest width of hind femur.	Length of humeral seta.	Length of longest apical abdominal bristle.	Length of longest bristle on epiproct.
bostrychophilus . .	3·06 (0·306, 50),[1]	4·34 (0·434, 50)	3·92 (0·620, 20)	5·17 (0·817, 20)	8·57 (1·355, 20)	4·37 (0·691, 20)	6·09 (0·963, 20)
subfuscus . . .	1·86 (0·240, 30)	3·00 (0·474, 20)	4·15 (0·656, 20)	3·06 (0·484, 20)	6·51 (1·029, 20)	3·37 (0·533, 20)	5·06 (0·800, 20)
simulans race A . .	1·95 (0·252, 30)	4·35 (0·513, 36)	7·48 (1·058, 25)	3·71 (0·479, 30)	4·94 (0·638, 30)	3·81 (0·492, 30)	3·22 (0·552, 17)
pubescens . . .	1·54 (0·199, 30)	2·54 (0·402, 20)	5·76 (0·911, 20)	3·22 (0·509, 20)	4·98 (0·787, 20)	2·88 (0·455, 20)	3·75 (0·593, 20)
liparus	2·35 (0·372, 20)	2·74 (0·433, 20)	5·29 (0·836, 20)	3·97 (0·628, 20)	4·85 (0·767, 20)	3·24 (0·512, 20)	— — —
rufus	2·25 (0·318, 25)	5·10 (0·721, 25)	6·75 (0·955, 25)	3·84 (0·523, 27)	6·67 (0·943, 25)	5·70 (0·806, 25)	6·06 (0·857, 25)
entomophilus . . .	2·48 (0·226, 60)	3·56 (0·563, 20)	8·24 (1·165, 25)	4·31 (0·393, 60)	6·02 (0·673, 40)	4·05 (0·453, 40)	8·99 (1·180, 29)
terricolis	2·16 (0·342, 20)	3·95 (0·610, 21)	7·00 (1·107, 20)	3·62 (0·467, 30)	4·83 (0·764, 20)	2·07 (0·327, 20)	4·25 (0·672, 20)
paetus	2·24 (0·224, 50)	3·26 (0·364, 40)	4·44 (0·444, 50)	3·74 (0·374, 50)	8·54 (1·208, 25)	6·04 (0·604, 50)	7·98 (1·128, 25)
paetulus	1·12 (0·158, 25)	3·12 (0·336, 43)	2·34 (0·331, 25)	3·13 (0·443, 25)	4·47 (0·632, 25)	2·97 (0·420, 25)	3·44 (0·487, 25)

[1] The figures in brackets are standard error of the coefficient of variability and number of items in the sample.

(*b*) Males.

Species.	Width of head capsule.	Antennal length.	Length of 4th antennal segment.	Greatest width of hind femur.	Length of humeral seta.	Length of longest apical abdominal bristle.	Length of longest bristle on epiproct.
subfuscus . . .	1·30 (0·168, 30)	3·44 (0·544, 20)	3·41 (0·539, 20)	3·31 (0·523, 20)	9·85 (1·557, 20)	3·28 (0·519, 20)	5·88 (0·930, 20)
simulans race A . .	2·52 (0·356, 25)	7·16 (1·132, 20)	5·18 (0·819, 20)	4·03 (0·570, 25)	4·28 (0·677, 20)	5·02 (0·725, 24)	3·02 (0·755, 8)
pubescens . . .	2·30 (0·297, 30)	4·03 (0·637, 20)	6·63 (1·048, 20)	4·19 (0·662, 20)	3·95 (0·624, 20)	3·87 (0·612, 20)	5·08 (0·803, 20)
liparus	1·35 (0·213, 20)	2·40 (0·379, 20)	5·65 (0·893, 20)	5·53 (0·874, 20)	6·09 (0·963, 20)	7·23 (1·143, 20)	— — —
rufus	1·84 (0·291, 20)	4·01 (0·567, 25)	3·94 (0·623, 20)	3·33 (0·526, 20)	9·82 (1·552, 20)	5·39 (0·852, 20)	5·31 (0·840, 20)
entomophilus . . .	1·57 (0·188, 35)	3·90 (0·436, 40)	4·99 (0·706, 25)	4·70 (0·525, 40)	6·10 (0·691, 39)	3·20 (0·428, 28)	5·86 (0·783, 28)
terricolis	2·50 (0·395, 20)	3·76 (0·580, 21)	6·82 (1·078, 20)	4·54 (0·718, 20)	6·95 (1·098, 20)	5·65 (0·893, 20)	5·49 (0·868, 20)
paetus	2·10 (0·210, 50)	3·55 (0·355, 50)	6·01 (0·601, 50)	3·13 (0·313, 50)	8·73 (1·952, 10)	6·29 (0·629, 50)	5·70 (0·736, 30)
paetulus	1·44 (0·204, 25)	2·16 (0·306, 25)	3·68 (0·520, 25)	2·86 (0·404, 25)	3·61 (0·511, 25)	2·47 (0·349, 25)	4·41 (0·624, 25)

difference between the two coefficients greater than 1·64 times the square root of the sum of the squares of the two standard errors has been regarded as significant. The significant differences at a 5 per cent. probability level have also been determined ($V_1 - V_2 > 2 \times \sqrt{SE_1^2 + SE_2^2}$ regarded as significant).

Results.—A. *Comparison of the parthenogenetic* bostrychophilus *with the bisexual species.* Taking each of the seven characters in turn, the coefficient for *bostrychophilus* has been compared with the female coefficient for each of the nine bisexual species. This gives 62 comparisons (the curvature of the bristle on the epiproct of *liparus* precludes statistical treatment). At the 5 per cent. probability level *bostrychophilus* has a significantly larger coefficient of variability than the bisexual species in 22 of the 62 comparisons and a significantly smaller coefficient in only 4 cases, all of which refer to the 4th antennal segment. At the 10 per cent. probability level (Table X) *bostrychophilus* has a significantly larger coefficient in 29 cases and a significantly smaller coefficient in 6 cases, 5 of which refer to the 4th antennal segment. In two comparisons a doubtfully significant difference is recorded. The anomalous result given by the 4th antennal segment is probably due to the chance draw of an unrepresentative sample of *bostrychophilus* for the measurement of this character. It is not reflected in the figures for the antennal length since two independent samples of *bostrychophilus* were used for the measurements of these two characters. Ten measurements of the 4th antennal segment taken at an earlier date from the same culture of this species have been incorporated with the sample of 20 used for the above comparisons. The data for the combined sample are: $V = 7{\cdot}136$, standard error of $V = 0{\cdot}921$, $N = 30$. When this is compared with the coefficients of the bisexual species, *bostrychophilus* is significantly more variable than *subfuscus*, *paetus* and *paetulus*, and no significant difference is found in the comparisons with the remaining six species at both 5 per cent. and 10 per cent. probability levels. Replacing the original data of the 4th antennal segment by this result, *bostrychophilus* has a significantly

TABLE X.—*Results of Significance Tests at* 10 *per cent. Probability Level. Difference between Coefficients of Variability of the Parthenogenetic* Liposcelis bostrychophilus *and those of Nine Bisexual* Liposcelis *Species.*

Species.	Width of head capsule.	Antennal length.	Length of 4th antennal segment.	Greatest width of hind femur.	Length of humeral seta.	Length of longest apical abdominal bristle.	Length of longest bristle on epiproct.
subfuscus .	>	>	—	>	—	—	—
simulans .	>	—	<	—	>	—	>
pubescens .	>	>	<	>	>	>	>
liparus .	—	>	—	—	>	—	
rufus . .	>	—	<	—	—	—	—
entomophilus .	—	—	<	—	>	—	<
terricolis .	>	—	<	>	>	>	—
paetus . .	>	>	—	doubtfully significant	—	doubtfully significant	—
paetulus .	>	>	>	>	>	>	>

> (<) indicates that the coefficient of variability for *bostrychophilus* is significantly greater (smaller) than that for the species tabled.   indicates no significant difference.

larger coefficient of variability at the 10 per cent. probability level in 31 of the 62 comparisons (in 24 at 5 per cent. level) and has a significantly smaller coefficient in only one of the 62 comparisons (in none at 5 per cent. level) when compared with nine bisexual species. The general conclusion then would appear to be that the parthenogenetic species is more variable than the bisexual species under these conditions of culture.

B. *Comparison of females with males.* The results of the comparisons of male and female coefficients for each character and species are given in Table XI.

TABLE XI.—*Results of Significance Tests at 10 per cent. Probability Level. Difference between Coefficients of Variability of Females and Males in Nine* Liposcelis *Species.*

Species.	Width of head capsule.	Antennal length.	Length of 4th antennal segment.	Greatest width of hind femur.	Length of humeral seta.	Length of longest apical abdominal bristle.	Length of longest bristle on epiproct.
subfuscus	♀	—	—	—	♂	—	—
simulans	—	♂	♀	—	—	—	—
pubescens	♂	♂	—	—	—	—	—
liparus	♀	—	—	—	—	♂	
rufus	—	—	♀	—	♂	—	—
entomophilus	♀	—	♀	—	—	—	♀
terricolis	—	—	—	—	—	♂	—
paetus	—	—	♂	—	—	—	♀
paetulus	—	♀	♂	—	—	—	—

♀ (♂) indicates that the female (male) has a significantly greater coefficient of variability than the male (female) for the character and species tabled.

— indicates no significant difference between the variabilities of the two sexes.

At the 10 per cent. probability level a significant difference is present in 18 of the 62 comparisons. In 9 of these the coefficient for the male is larger than that for the female and in the other 9 cases the female coefficient is the larger. At the 5 per cent. level 12 comparisons show a significant difference, the female being more variable than the male in 6 cases and the male being the more variable sex in the other 6. There would seem to be no consistent difference between the sexes in variability either for a single character over the nine species or within any single species.

SUMMARY.

1. The position of the genus *Liposcelis* in the Corrodentia is considered, the following taxonomic groupings being characterized and briefly reviewed: The major groupings NANOPSOCETAE and ATROPETAE, the two families of the NANOPSOCETAE, PACHYTROCTIDAE and LIPOSCELIDAE and the genera *Embidopsocus s. str.* and *Liposcelis*.

2. A revision of the genus *Liposcelis* is presented. Twenty-two species (excluding the two fossil species) are recognized. The species show a permutation of characters which renders subgeneric grouping impossible. A review of habitats, geographical distribution and biology is given, together with keys for the identification of males and females.

Four new species are described—*myrmecophilus*, *paetulus*, *rufus* and *simulans*—and two new synonyms—*L. silvarum* (Kolbe, 1888) = *L. formicarius* (Hagen, 1865) and *L. luridus* Broadhead, 1947 = *L. terricolis* Badonnel, 1945. *L. divinatorius* is unrecognizable and is placed in *incertae sedis* with five others of uncertain identity.

3. Coefficients of variability for seven characters of ten *Liposcelis* species are given, the samples measured in every case being derived from cultures reared under constant conditions of temperature, humidity and food. One of these species, *bostrychophilus*, is parthenogenetic and male-less. The remaining nine species are bisexual and parthenogenesis does not occur. The parthenogenetic species would appear to be more variable than the bisexual species under these conditions of culture. There is no consistent difference between the sexes in variability.

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This work has been carried out in the Departments of Zoology at Exeter and Leeds. I wish to express my thanks to Professor L. A. Harvey and to Professor E. A. Spaul for the Departmental facilities which they have afforded me. Dr. A. Badonnel has lent me the type specimens of several species and I have been able to examine other type material through the kindness of Dr. J. C. Bequaert, of the Museum of Comparative Zoölogy, Harvard College, Mr. N. D. Riley, of the British Museum (Nat. Hist.) and Mr. J. V. Pearman. Dr. Badonnel has also very kindly allowed me to use some of his unpublished measurements of North African and European specimens of *L. terricolis*. I also wish to express my sincere thanks to Dr. B. M. Hobby, particularly for the advice which he has given me on several problems of taxonomic procedure, and to Dr. B. L. Welch for his advice on statistical methods. The photographs of sculpturing were taken by Mr. W. Blackledge and Mr. D. A. Kempson, and their cost has been defrayed by a grant from Leeds University.

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EXPLANATION OF PLATES.

Sculpturing of cuticle of *Liposcelis* species, females (anterior end towards top of page).

PLATE I.

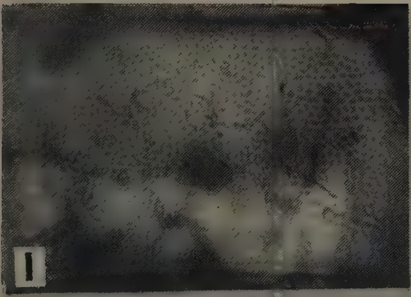
Figs. 1–7.—(1) *L. bostrychophilus*, 5th abdominal tergum (type specimen). (2) *L. simulans*, race A, 4th abdominal tergum. (3) *L. simulans*, race B, 3rd abdominal tergum. (4) *L. rugosus*, type specimen, vertex of head. (5) *L. rugosus*, type specimen, 3rd and 4th abdominal terga. (6) *L. rugosus*, paratype, vertex of head. (7) *L. rugosus*, paratype, 4th and 5th abdominal terga.

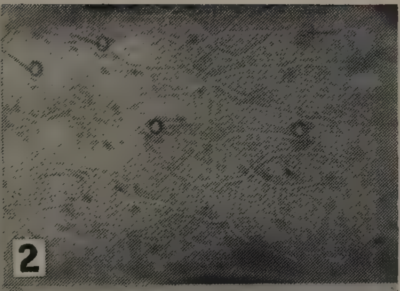
PLATE II.

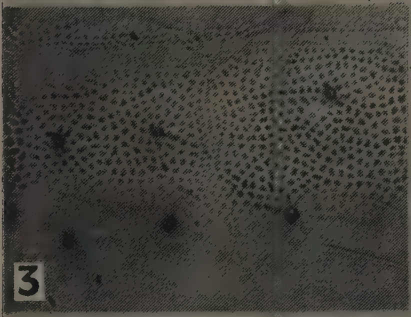
Figs. 8–13.—(8) *L. formicarius*, 6th abdominal tergum. (9) *L. myrmecophilus*, vertex of head. (10) *L. myrmecophilus*, 5th abdominal tergum. (11) *L. rufus*, vertex of head. (12) *L. rufus*, 4th abdominal tergum. (13) *L. entomophilus*, vertex of head.

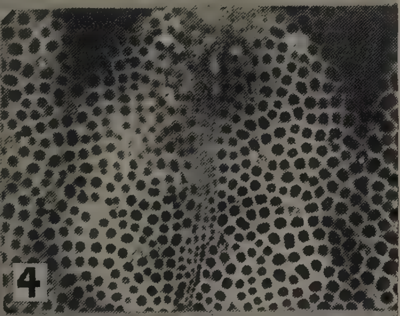
PLATE III.

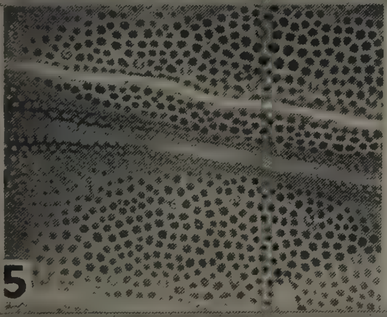
Figs. 14–19.—(14) *L. entomophilus*, 6th abdominal tergum. (15) *L. exiguus*, abdominal tergum. (16) *L. hirsutus*, 4th and 5th abdominal terga (the arrow points to those tubercles in focus). (17) *L. pictus*, 5th abdominal tergum. (18) *L. paetus*, 5th abdominal tergum. (19) *L. paetulus*, 5th abdominal tergum.

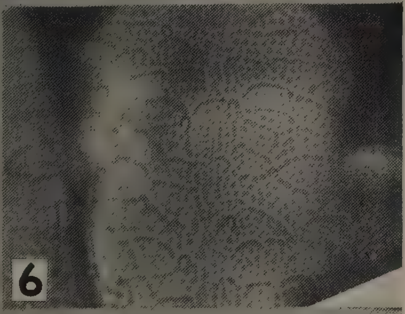


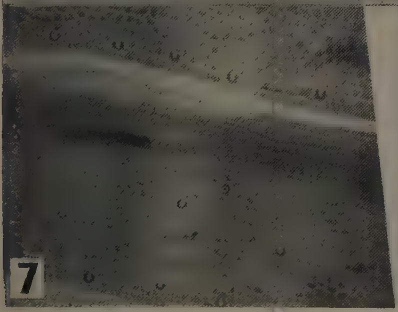


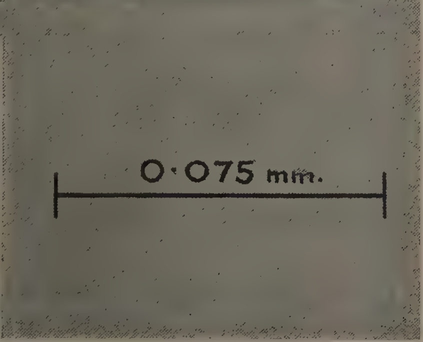












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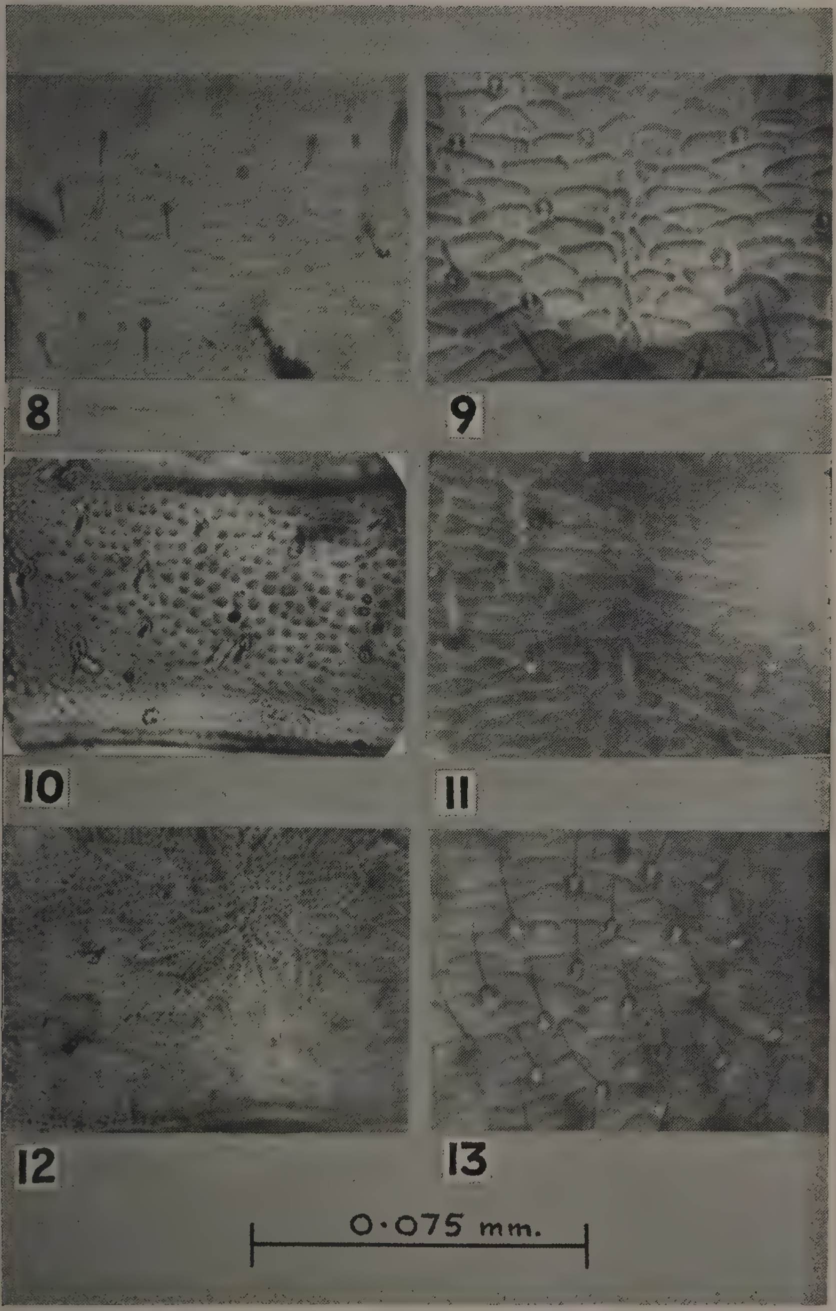

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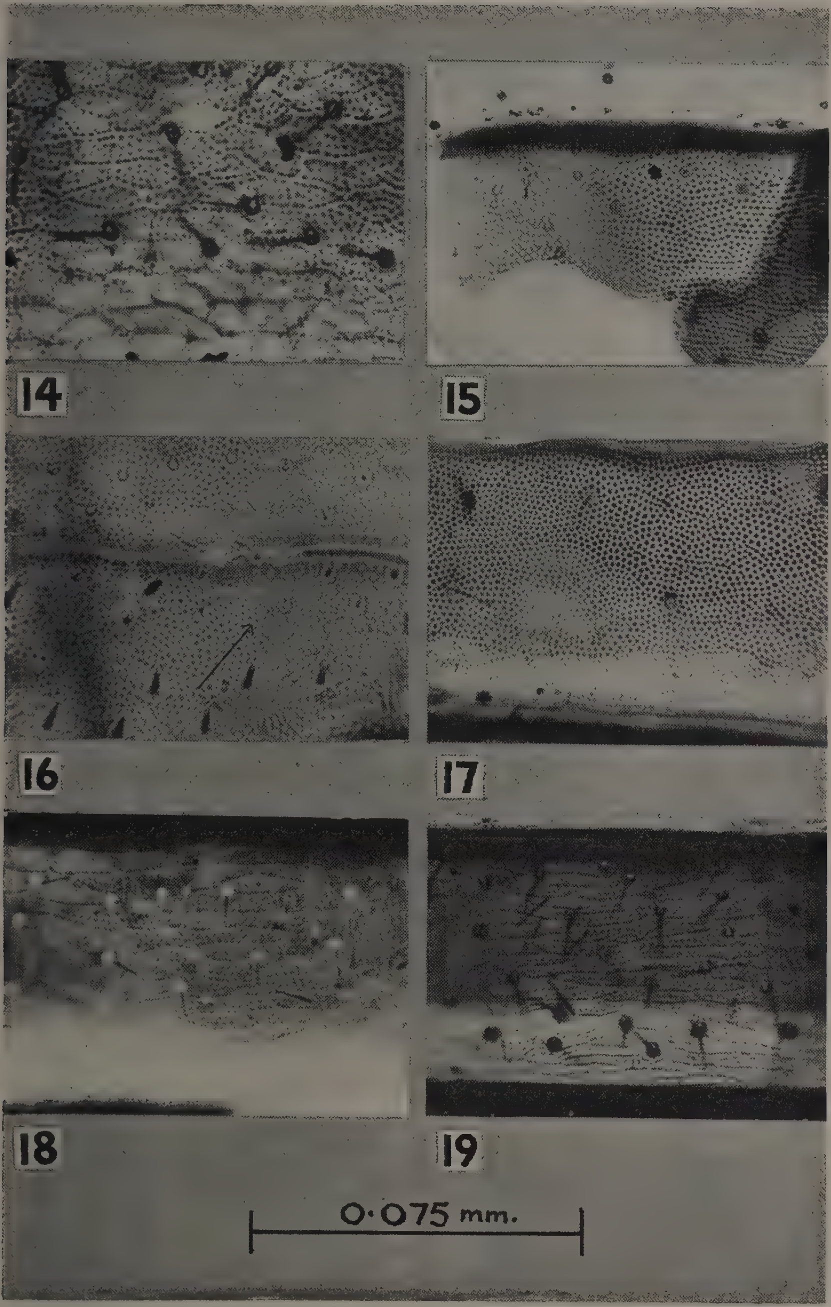

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THE IDENTITY OF SOME CRAMBINAE ASSOCIATED WITH SUGAR-CANE IN INDIA AND OF CERTAIN SPECIES RELATED TO THEM (LEPIDOPTERA : PYRALIDAE).

By A. P. Kapur, M.Sc., Ph.D., D.I.C.

(*Commonwealth Institute of Entomology.*)

Manuscript received 24th August, 1949.

(Read 3rd May, 1950.)

With 10 Plates.

Introduction.

The Crambine moths from India considered in this paper have hitherto been placed mostly in the genera *Chilo* Zincken, *Diatraea* Guilding and *Argyria* Hübner. Their larvae are usually associated with Gramineae. Some of them bore into the stems and are serious pests of sugar-cane, sorghum, maize, rice, etc., and they have therefore attracted considerable attention from the economic point of view. However, very little work has been done in recent years on their taxonomy, and their nomenclature is consequently in a state of confusion, and their relationships with one another are inadequately understood. The object of the present paper is the revision of the taxonomy of the more important species.

The bearing of such a study on the problems of control, particularly by biological means, is obvious. Owing mainly to the habits of the borers and the nature of the crops, control measures such as the application of insecticides have been found neither practical nor economical in India, and the methods usually advocated are, therefore, improved cultural practices and the use of the less susceptible varieties of the host plants. Lately, attempts have been made to introduce biological methods, but although the preliminary results of liberating the egg parasite, *Trichogramma minutum* Riley, were received locally with great enthusiasm, this parasite, though useful, has not proved entirely satisfactory. Much original work in the field of biological control remains to be done, and a more thorough knowledge of the pests and their natural enemies is urgently required. If the latter are to be employed for control purposes, it is necessary to know not only their identity, but also that of their hosts on both wild and cultivated plants, and a knowledge of the relationships between those host species that are pests and those that are not is also needed for a proper understanding of the problem. The present paper is not a full revision of the group, the material and time at the author's disposal being limited, but it is hoped that it will at least serve as a basis for such revision. The author has had the great advantage of working at the British Museum (Natural History), which is rich in type material. The types of almost all the important species dealt with here, and several more, have been examined. Most of these are in the British Museum, but a few, particularly the species from Java described by Snellen, were borrowed from the Rijksmuseum van Naturlijke Historie, Leiden, through the kindness of Dr. C. O. van Regteren Altena and of Mr. N. D. Riley, of the British Museum, who was instrumental in obtaining them. The writer is particularly grateful to Mr. W. H. T. Tams, also of the British Museum, who has been most generous with his help and advice based on his vast knowledge and experience of the group, and has also devoted much time and skill to the preparation of most of the photographs reproduced in this paper. Thanks are due to Dr. T. H. C. Taylor, of the Commonwealth Institute of Entomology, who has given encouraging support throughout the study and has offered valuable suggestions in reading through the manuscript. About two hundred moths, mostly bred from sugar-cane and sorghum, were received from Mr. P. V. Isaac and Dr. E. S. Narayanan, of the Indian Agricultural Institute, New Delhi. It is with great pleasure that their co-operation is acknowledged.

HISTORICAL.

Cotes (1889) was the first to attempt to give a specific name to the moth-borer of sugar-cane in India. He provisionally called it *Diatraea saccharalis* Fabricius, a species which was known to cause similar damage in the United States. Being aware of the unsatisfactory systematic position of the Indian species, he sent an example of it, bred from sugar-cane in Calcutta, to Dr. C. V. Riley, the United States entomologist, for comparison with the American species, and, in 1896, published Dr. Riley's report, which stated that the Indian species was not the same as the American one, and that the former was a *Chilo* and not a *Diatraea*. Owing to the poor condition of the specimen Dr. Riley did not give a definite identification, but suggested that it might be identical with *Chilo infuscatellus* Snellen, which infested sugar-cane in Java. Unfortunately, a comparison with the latter species does not seem to have been made. From the figures given by Cotes (1889, plate ii, figs. 2*a*–*g*), particularly the enlarged one of the pupa (*f*) showing the fringed ridges of the abdominal segments, it has been suggested (Gupta, 1940) and seems almost certain that his species was the same as *Argyria sticticraspis* Hampson (1919). An examination of the co-type (now made lectotype) of *Chilo infuscatellus* has revealed that it is identical with *Argyria sticticraspis*.

Cotes (1889, 1893) knew of two other species, one boring sorghum in Deccan and the other rice in Bombay. He did not name the former, but concerning the latter he remarked that it may possibly be "*Chilo oryzaeellus* (Rice stalk borer in the United State) or a species very closely allied to it." No further mention of this species has since been made in the literature on Indian borers.

In 1896 Sir G. F. Hampson published the fourth volume of moths in the *Fauna of British India* series, dealing with the family PYRALIDAE, and recorded seven species of *Chilo* and fourteen of *Argyria* (*Platytes* Guenée), but none of *Diatraea*. The name *Chilo simplex* Butler (erroneously applied later to a pest of sugar-cane) was first applied to a borer of economic importance by Barlow (1899, p. 217), who reported that the insect in question was injurious to *juar* [*sorghum*], *makai* [maize], etc., in Karachi, but this was not the first record of the occurrence of *Chilo simplex* in India.

In 1905 Dudgeon described *Chilo auricilia* from Bengal, and Lefroy (1906) made the following remark about it and *Chilo simplex*: "The moth-borers of India are of several species . . . *Chilo simplex* is certainly the only species widely spread as a pest in Western India. Quite recently it has been found that one of the moth-borers of Bengal is *Chilo auricilia*, a species extremely easily confused with *C. simplex*. . . . Years of work will be required to ascertain the range of various species. . . . It may be pointed out that though the difference between *Chilo simplex* and *Chilo auricilia* may be one that appeals only to the entomologists, the differences in their habits may be so great as to make the treatment of each quite distinct." However, the position remained unchanged till 1917, when T. B. Fletcher commenced publishing the results of his studies. He gave a final account of them in 1928.

In his *Report of the Imperial Entomologist for 1915–16*, Fletcher (1917*a*) stated that *Chilo simplex*[1] normally attacked cereals, and that there were two or three species of *Diatraea* which were borers in cane and only occasionally attacked cereals. In the following year (1917*b*, *c*) he gave specific names to two out of the three species of *Diatraea* which he had then been able to sort out. These were *Diatraea suppressalis* (*auricilia*) and *Diatraea venosata* (*striatalis*)[*sic*]. In regarding *Chilo auricilia* Dudgeon as a synonym of *Chilo suppressalis* Walker he had followed Hampson (1912, p. 1250), but in the following year (1918), on examining certain specimens identified by Dudgeon himself, he concluded that these two forms were distinct species. He also doubted the validity of regarding *Diatraea striatalis* Snellen as a synonym of *venosata* Walker, and much more recently (1942) Vinson has regarded them as distinct species.

From then onwards, pending a revision of the whole group, Fletcher referred to the unnamed species by cage-slip numbers. Out of a total of twelve different species of CRAMBINAE recorded by Fletcher and Ghosh (1920), only four were specifically named; these were *Chilo simplex*, *Chilo auricilia*, *Diatraea venosata* and *Argyria tumidicostalis* Hampson. In 1928 Fletcher pointed out that what he had previously called *Chilo simplex* and *Chilo auricilia* were, in fact, *Chilo zonellus* Swinhoe and *Argyria sticticraspis* Hampson respectively. He further stated that a species with cage-slip No. 1674 was *Diatraea auricilia* Dudgeon, and that the remaining unnamed species were new. He consequently named them as follows: *Chilo oryzae*, *Chilo saccharicola*, *Diatraea kanra*, *Diatraea batri* and *Diatraea ikri*. It may be noted that *Chilo simplex* Butler, so commonly mentioned in earlier literature, was not included in the revised list published by Fletcher in 1928. Kawada (1930) proposed that *Chilo oryzae* was synonymous with *Chilo simplex*, which, according to Bisset (1939), was itself a synonym of *Chilo suppressalis* Walker.

Subsequent workers in India, notably Isaac (1933, 1936, 1940, etc.), Pruthi (1936, 1937), Pruthi and Narayanan (1938, 1939) and Gupta (1940) have mostly followed the nomenclature proposed in Fletcher's revised list mentioned above. The only other species which has come lately into the picture of sugar-cane pests in India (*vide* Rahman and Tandon, 1940) is *Chilo trypetes* Bisset (1939), which, as will be shown in the present paper, is synonymous with *Chilo steniellus* Hampson (1898) and *Chilo griseoradians* DeJoannis (1930), and belongs to a new genus.

In 1942 Vinson pointed out that "*Diatraea venosata* (Walker) from India," although closely related to *Diatraea mauriciella* (Walker), was nevertheless a distinct species. Tams (1942) suggested that the latter is a synonym of *Proceras sacchariphagus* Bojer, and further pointed out that the Mauritian species is not congeneric with the New World species, *Diatraea saccharalis* (Fabricius), which is the genotype of *Diatraea*. This would naturally result in the transferring of "*venosata* from India" to the genus *Proceras* Bojer owing to its close relationship with the genotype of the latter. This opened up a new field for further investigations, the results of which are reported in the present paper, into the relative positions of the remaining species from India that have hitherto been placed under *Diatraea* and of various other species that have been confused with them.

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[1] According to Fletcher's later (1928) report this was, in fact, *Chilo zonellus* Swinhoe.

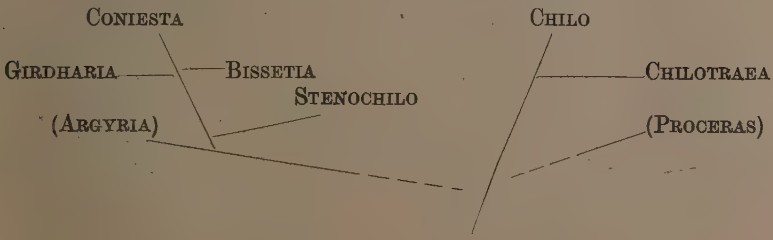
METHOD OF STUDY.

Examination of the frons and ocelli often necessitates scraping off most of the scales from the head. The venation is easily studied by applying toluene with a brush; the veins are designated in this paper by the same numerical system as was adopted by Hampson. For a study of the genitalia, the whole abdomen must usually be completely removed and soaked overnight with 5 to 10 per cent. (depending upon the size of the specimen) caustic potash solution without heating; after the usual cleaning and dehydration the material is best studied in alcohol, and it can later be mounted on a slide if desired. Of the male genitalia, the harpes and vinculum are best seen in the front view and spread out, and the uncus and gnathos in lateral or semilateral views; where the anellus shows important characters it should be separated for the purpose of illustration. As regards the female genitalia, the area round the ostium may be cleared of scales and hairs, and the abdomen split on the side and spread to expose the ductus bursae and the bursa copulatrix, which usually show important characters. The nomenclature followed in the descriptions of the genitalia is that adopted by Busck and Heinrich (1921).

Key to the Genera considered in the present paper.

1. Frons subrounded; apex not or only slightly pointed, without a corneous point . . . . . 2.
    Frons conical; apex always with a corneous point 3
2. Frons not produced forward (Pl. I, fig. 6); ocelli absent . *Proceras* Bojer.
    Frons produced forward (Pl. I, figs. 1,2); ocelli present *Chilotraea* gen. n.
3. Fore wing with veins 11 and 12 free . . . . . 4.
    Fore wing with vein 11 anastomosing with 12 . . . . . 6.
4. Fore wing with veins 6 and 7 shortly stalked; palpi short (one and a half times the length of frons) . . . . . *Stenochilo* Hampson.
    Fore wing with veins 6 and 7 not stalked; palpi long (three times the length of frons) . . . . . 5.
5. Ocelli present; antennae minutely serrate (Pl. VIII, fig. 8) *Chilo* Zincken.
    Ocelli absent; antennae distinctly serrate (Pl. VIII, fig. 10) *Bissetia* gen. n.
6. Fore wing with veins 4 and 5 stalked; palpi short (equal to the length of the head) . . . . . *Drasa* gen .n.
    Fore wing with veins 4 and 5 not stalked; palpi long (over twice the length of the head) . . . . . 7.
7. Antennae in the male pectinate; ocelli well developed . . *Girdharia* gen. n.
    Antennae in the male minutely serrate or almost setaceous; ocelli poorly developed . . . . . *Coniesta* Hampson.

A small proportion of individuals belonging to certain species of *Chilotraea* exhibit variations in the shape of the frons and in the confluence of the veins 11 and 12 of the fore wing. It is therefore desirable to examine long series of examples where possible. The external characters employed in the key correlate with the characters of the male genitalia, which have been one of the chief guiding factors in the classification presented in this paper. The genitalic characters have been omitted from the key to facilitate its use. With a few exceptions the female genitalia do not offer striking generic characters, but for distinguishing the species they are as valuable as the male genitalia. The external characters employed in the present study have often been used by earlier workers on the Crambinae, notably Hampson, Meyrick, Dyar and Heinrich. The shape of the frons has been more recently used in the classification of the Crambine moths and it is indeed of great value, but it must be used with caution because in several genera that are not very closely related to one another the frons is similar in shape. The genus *Drasa*, for instance, has a conical frons with a corneous apex as is the case in *Chilo* and *Coniesta*, but because of its venation (fore wing with vein 4 and 5 stalked) and the structure of the genitalia it is undoubtedly a distinct genus, which is not closely related to either of these two genera. Some confusion has hitherto existed regarding those genera in which the frons is produced forward and is usually conical, with a corneous point at the apex, and the fore wings have veins 11 and 12 either confluent or separate, but are otherwise similar. The structure of the genitalia seems to throw some light on the relationship in these cases, and the conclusions thus reached are likely to be confirmed when more is known of their biology and the morphology of the early stages. Such genera, considered in this paper, can be divided into two major groups, one of which consists of *Chilo* with *Chilotraea* as its close ally, and the other comprises *Coniesta*, *Girdharia*, *Bissetia* and *Stenochilo*. The male genitalia of the *Chilo* group are characterized by the usually simple and undivided harpes, the short and beak-like uncus and gnathos and the elaborately developed anellus and aedeagus. In the *Coniesta* group the harpes are well developed and are usually divisible into three parts, one of which is often densely hairy, the uncus and gnathos are large and variously shaped and the anellus and aedeagus are usually small and simple in outline. The female genitalia are more variable within each group than the male genitalia, with the result that a comparison between the two groups based on the former cannot be made without referring to the various species-groups in each genus. On the whole, the *Coniesta* group shows greater affinities with the genus *Argyria* (*sens. lat.*) than with *Chilo* or *Proceras*, although it is probable that *Chilo* provided the main stock from which the other genera mentioned above have evolved. Their probable general relationship with one another may be represented diagrammatically as follows :



Chilo Zincken.

Chilo Zincken, 1817 : 36. Hampson, 1895 : 922, 954 ; 1896 : 10, 26.
Genotype : *Tinea phragmitellus* Hübner, 1805–1810.

Referable to the sub-family CRAMBINAE. Frons produced forward and conical, with a distinct corneous point at the apex, sometimes with a part of the ventral surface flattened and produced as an indistinct ridge. Ocelli present, well developed. Antennae in the male minutely serrate (Pl. VIII, fig. 8) and ciliate ; in the female setaceous. Proboscis poorly developed ; labial palpi porrect, slightly down-curved, covered with long scales and hairs, and two to three times the length of the head ; maxillary palpi triangularly dilated with scales. Fore wing with vein 3 arising before the lower angle of the cell ; 4 and 5 separate at origin ; 6 from below from the upper angle (apex) of the cell ; 7 from the apex ; 8 and 9 stalked, arising a little away from 7 ; 10 from near the base of 8+9 ; 11 curved forward to lie close to 12, but not anastomosing with it. Hind wing with veins 4 and 5 arising from the same point or very shortly stalked, from the lower angle of the cell ; 6 from the upper angle ; 7 and 8 stalked.

Male genitalia.—Vinculum **V**-shaped, rounded at the apex. Harpes undivided, broadly triangular to subquadrangular. Costa simple or with a blunt subcostal projection, with moderately long hairs. Tegumen triangular, as broad at base as long at the sides, which are heavily sclerotized and are without any basal or lateral lobes. Uncus and gnathos also triangular, short, beak-like, with the apices pointed. Anellus consisting of a small or large and slightly curved plate with well-developed lateral arms, which are sometimes very long and slender. Aedeagus narrow and fairly long, sometimes partly split into two (upper and lower) halves.

Female genitalia.—Ovipositor (Pl. III, figs. 12, 14) normal, moderately long and with two pairs of apophyses. Ostium moderately to heavily sclerotized, sometimes covered by the genital plates, which may be notched or bilobed anteriorly. Ductus bursae long or short, distinctly more heavily chitinized when short. Bursa copulatrix large, with or without a signum.

Range: World-wide distribution.

Remarks: The genotype comes from Europe. Of the material examined, four species from India seem to belong to this genus, while a large number of the Indian species hitherto placed in it are not considered by the present author to be congeneric with the genotype. In one instance, as he has already pointed out (Kapur, 1948), a New World species, *Epina dichromella* Walker, had been considered to belong to this genus and was erroneously recorded from India and Ceylon (Hampson, 1896 ; Vinson, 1942). The generic positions of many Indian species hitherto placed in *Chilo* are revised in the present paper, but a few that are apparently not closely related to the genera here considered have been left for future study.

Key to the Species of the Genus *Chilo*.

(a) *Based on size, coloration and structure of the frons.*

1. Ventral surface of the frons partly flattened and produced as a ridge 2.
Ventral surface of frons uniformly smooth ; without any ridge . . . 4.
2. Fore wing with anterior angle distinctly more acute in female than in male ; light straw-coloured in female, straw-coloured to brownish in male, with usually a dark spot immediately outside the cell, darker scales tending to form streaks on and between the veins, less distinct in female ; series of dark spots on termen rather diffuse ; fringe slightly darker near base. (Europe ; West and Central Asia) *phragmitellus* (Hübner).

Fore wing with anterior angle in female only slightly more acute than in male; straw-coloured to cinnamon brown, slightly lighter in female, with dark specks distributed irregularly and not confined to and seldom on the area along the veins; series of spots on termen distinct 3.

3. Fore wing in both sexes rather uniformly cinnamon brown, with dark brown specks or spots which are very few in female and which in male form a transverse series of three blackish dots on the disk; fringe shiny, uniformly coloured, rather golden brown. (Korea; Japan) . . . . *luteellus* (Motschulsky).

Fore wing straw-coloured to brown, usually lighter in female, with numerous small, dark brown specks dispersed irregularly all over, sometimes forming patches on the disk; fringe lighter distally, not distinctly shiny. (Siberia, Japan, Korea, Formosa, China, Malaya, India, Ceylon) . . . . *suppressalis* (Walker).

4. Size large; expanse of female 40 mm. (male unknown); fore wing light straw-coloured, with a piceous spot situated just outside the cell, between the bases of veins 5 and 6; series of black spots on termen oblong. (India) . . . . *tamsi* sp. n.

Size relatively small, wing expanse of female usually not more than 30 mm., male smaller; fore wing whitish to cinnamon brown, with numerous dark brown to piceous scales forming either several rather diffuse spots or fasciae; series of spots on termen not oblong . . . 5.

5. Fore wing whitish brown, with dark brown to piceous scales usually forming a streak on costa, three rather diffuse spots on disk and a shadowy band running from apex towards centre of hind margin but stopping half way; series of spots on termen small, entire, piceous or black; fringe slightly darker near base. (India) . . *zonellus* (Swinhoe).

Fore wing cinnamon brown, suffused with reddish to dark brown, with a few irregularly dispersed scales and a rather diffuse dark brown fascia on the median nerve and extending a little beyond the cell; series of black spots on termen with silvery-white points in the middle; fringe much darker at base. (North-east India) *tumidicostalis* (Hampson).

(b) *Based on characters of the male genitalia.*

1. Aedeagus undivided, club-shaped . . . . 2.

Aedeagus divided for the greater part of its length . . . . 3.

2. Harpe subtriangular; arms of anellus moderately long, each with a triangular knob at apex (Pl. II, fig. 7). . . . . *phragmitellus* (Hübner).

Harpe quadrangular, arms of anellus very long, each with an elongate, subcylindrical knob at apex (Pl. II, fig. 4) . . *luteellus* (Motschulsky).

3. Harpe with a blunt subbasal projection at the costal margin (Pl. II, fig. 3); anellus with a large basal plate and short arms which are knobbed at apices (Pl. III, fig. 8) . . . . *zonellus* (Swinhoe).

Harpe with costal margin entire, without a projection; anellus with either a small basal plate and long arms or without a distinct plate, and with short arms which are not knobbed at apices . . . . . . 4.

4. Harpe quadrangular; anellus with a small basal plate and long arms each of which has two sharp conical teeth on the outer margin (Pl. II, fig. 5). . . . . *tumidicostalis* (Hampson).

Harpe triangular; anellus without a distinct basal plate, with short arms which are usually enlarged in the middle and pointed at apex (Pl. III, fig. 7) . . . . *suppressalis* (Walker).

(c) *Based on characters of the female genitalia.*

1. Genital opening with a chitinous shield projecting from its lower margin 2.
   Genital opening without a chitinous shield . . . . 3.
2. The chitinous shield broad, with the distal part divided into subrounded halves bearing prominent, longitudinal wrinkles (Pl. III, fig. 15*c*) *zonellus* (Swinhoe).
   The chitinous shield elongate, widely notched at the distal margin and only slightly wrinkled (Pl. III, figs. 14,*s*..) . . . . *tamsi* sp. n.
3. Ductus bursae short, in parts heavily chitinized, bursa copulatrix moderately large, without a signum . . . . 4.
   Ductus bursae long, poorly but uniformly chitinized ; bursa copulatrix very large, with a signum (Pl. III, fig. 12, 13) . . *suppressalis* (Walker).
4. Bursa oval ; ductus bursae uniformly chitinized near the base and with longitudinal ridges distally ; rim of genital opening without a chitinized band . . . . 5.
   Bursa elongate, sausage-like, three times as long as wide ; ductus bursae heavily chitinized on the sides near the base, without longitudinal ridges ; rim of genital opening with a distinct chitinized band (Pl. III, fig. 11) . . . . *tumidicostalis* (Hampson).
5. Ductus bursae with the chitinized part at the base nearly as long as wide (Pl. III, fig. 10) . . . . *phragmitellus* (Hübner).
   The same part a little more than twice as long as wide *luteellus* (Motschulsky).

Chilo phragmitellus (Hübner) (Pl. I, fig. 7 ; Pl. II, figs. 1, 6, 7 ; Pl. III, figs. 4,10).

Tinea phragmitellus Hübner [1805–1810].
Chilo phragmitellus (Hübner), Zincken, 1817 : 36.

♂. Fore wing straw-coloured, with brown to dark brown scales, usually forming a dark spot at the extremity of the cell and tending to form streaks on and between the veins ; the series of terminal spots lightly piceous and rather diffuse ; fringe slightly darker near the base. Hind wing slightly paler. Frons (Pl. I, fig. 7) conical, with a distinct corneous point ; ventral surface near the base flattened and produced into a circular ridge. Labial palpi about three times the length of the head.

♀. Larger, with the anterior angle of the fore wings distinctly more acute than in the male ; fore wing light straw-coloured and with fainter streaks, hind wing whitish.

Male genitalia.—Harpe (Pl. II, fig. 1) subtriangular, costa simple, straight. Uncus (fig. 6) triangular, sides slightly longer than the base, apex rather blunt, with sparse and moderately long setae. Gnathos slightly more heavily sclerotized than uncus, apex sharply pointed. Anellus (fig. 7) with the basal plate rather small, with a pair of lateral arms moderately long, unequal in length, slender, each with a triangular knob. Aedeagus (Pl. III, fig. 4) club-shaped with indistinct cornutus and several longitudinal striations distally.

Female genitalia.—The genital opening not surrounded by heavily sclerotized parts ; ductus bursae short, the heavily sclerotized part (fig. 10) close to the genital opening nearly as long as broad, the rest of the ductus with longitudinal striations ; bursa copulatrix moderately large, without a signum.

Expanse : ♂, 23–28 mm. ; ♀, 28–35 mm.

Material examined : 12 males and 15 females from the following localities :
EUROPE : Central Europe, mostly Zeller's collection ; England.
Also known from West-Central Asia and Turkestan.

Biological note : In England its larva bores into the stem of *Arundo phragmites* (GRAMINEAE), and has been described by Buckler (1901 : 321–323).

Remarks : Close to *Chilo luteellus* (Motschulsky) from Korea and Japan, from which it may be distinguished by the characters given in the keys.

Chilo luteellus (Motschulsky) (Pl. II, fig. 4 ; Pl. III, fig. 5).

Schoenobius luteellus Motschulsky, 1866 : 199.
Chilo luteellus (Motschulsky), Hampson, 1895 : 956. Shibuya, 1928 : 144.
Chilo gensanellus Leech, 1889 : 103. Shibuya, 1928 : 144. (Syn. n.)

♂. Fore wing rather uniformly cinnamon brown, with dark brown and a few black scales forming three (? four) blackish spots on the disk and a series (seven) on the termen ; fringe shiny, uniform, golden brown. Hind wing slightly paler. Frons similar in shape to that of *C. phragmitellus* ; labial palpi twice the length of the head.

♀. Larger, with the anterior angle of the fore wing slightly more acute than in the male ; fore wing cinnamon brown with a few scattered darker scales ; hind wing whitish.

Male genitalia.—Similar to those of *C. phragmitellus* except : Harpe (Pl. II, fig. 4) quadrangular ; arms of anellus very long, each with an elongate, subcylindrical knob at apex ; aedeagus (Pl. III, fig. 5) club-shaped with short spinous cornuti distally.

Female genitalia.—Also similar to those of *phragmitellus*, except that the chitinized part towards the base of the ductus bursae is longer, being a little over twice as long as wide.

Expanse : ♂, 23 mm. ; ♀, 29–30 mm.

Type : *Chilo gensanellus* Leech (♂, from Gensan, Korea), in the British Museum (Natural History). The type locality for *luteellus* is Japan.

Material examined : One male and three females from the following localities :

KOREA : Gensan, —.vi.1887 (*Leech*).

JAPAN : Exact locality not given.

Remarks : Shibuya (*l.c.*) placed *C. luteellus* next to *C. gensanellus*, and was aware of only three female examples of the former and two males of the latter. Neither he nor any other author seems to have known the male of the former or the female of the latter. Leech's (1901 : 397) identification of the male of *luteellus* is wrong, his example being in fact *C. suppressalis*. The type localities, namely, Japan and Korea, for *luteellus* and *gensanellus* are close to each other. The female examples of *luteellus* from Japan in the British Museum show a striking resemblance to the male of *gensanellus* in coloration, etc. A further indication that they are the same species is afforded by the structure of the genitalia. It will be observed that the female genitalia of *phragmitellus* and of *luteellus* are very similar, and it is, therefore, probable that the male genitalia of these two species are also similar. The male genitalia of *phragmitellus* resemble closely those of the type of *gensanellus*, which, according to the opinion adopted here, is the same as *C. luteellus* (Motschulsky). The matter could be settled satisfactorily only if the type of the latter were available, but Motschulsky's types are not easily traceable.

Chilo suppressalis (Walker) (Pl. II, fig. 2 ; Pl. III, figs. 1, 6, 7, 12, 13).

Crambus suppressalis Walker, 1863 : 166.
Chilo suppressalis (Walker) Hampson, 1895 : 957 ; 1896 : 27.
Jartheza simplex Butler, 1880 : 690.

Chilo simplex (Butler) Hampson, 1895 : 957 ; 1896 : 26. Bisset, 1939 : 47.
Chilo oryzae Fletcher, 1928 : 59. Kawada,[2] 1930 : 145. Kinoshita and Kawada, 1932 : 102–104.

♂. Fore wings straw-coloured, wholly suffused with light brown, with minute, brown to rather dark brown specks dispersed irregularly all over, and sometimes forming small patches ; terminal series of spots dark brown to piceous ; fringe not very shiny, of lighter colour distally. Hind wings whitish, with a shade of brown near the costa and apex ; fringe also uniformly whitish. Frons conical, with a corneous point and with a small ridge on the underside. Labial palpi a little over twice the length of head.

♀. Slightly larger than the male. Fore wings usually paler and with fewer dark specks. Hind wing uniformly whitish.

Male genitalia.—Harpe (Pl. II, fig. 2) subtriangular, distinctly narrower towards the apex ; costa simple, straight and without a projection. Uncus (Pl. III, fig. 6) triangular, with the sides a little longer than the base, narrowed distally, sharply pointed at the apex, and with a few short setae. Gnathos similar, but slightly more acute apically, without setae. Anellus (fig. 7) without a flat plate below the aedeagus, forming a ring round the latter, and with the lateral arms enlarged and flattened in the middle and much narrowed distally. Aedeagus (fig. 1) long, bifurcate in the distal two-thirds of the length, the lower part narrower, equal to or only a little shorter than the upper ; the two opposing surfaces of these parts flat, and slightly more heavily sclerotized than the rest of the aedeagus.

Female genitalia.—Genital plates absent ; the ostium partly surrounded by an oblique sclerotized area (fig. 13). Ductus bursae (fig. 12) very long and narrow, uniformly but weakly chitinized ; bursa copulatrix large, signum small.

Expanse : ♂, 20–25 mm. ; ♀, 24–30 mm.

Types : Crambus suppressalis Walker (♀, China, Shanghai) ; *Jartheza simplex* Butler (♂, Formosa) ; *Chilo oryzae* Fletcher (♀, India, Pusa) ; all in the British Museum.

Material examined : 72 males and 60 females from the following localities :

U.S.S.R. : Ussuri region, Siberia, Vinogradovka, at light, 6.vii.1929 (*Deakonov Philip*).

JAPAN : Kiushiu (*Leech*) ; Ohoki, Iyo, Shikoku, 1.vi.1896 (*A. E. Wileman*) ; Yoshimo, Yamato, Honshu, 23.vi.1900, 26.vi.1899, 9.vii.1899, 10.vii.1899, 30.viii.1899, 8.ix.1899, 28.v.1900, 9.vi.1900, 24.viii.1900, 20.vi.1901 (*A. E. Wileman*) ; Hakodate, —.vi, vii, 1887 (*Leech* Coll.) ; Kobe, 24.vi.1924 (*J. E. A. Lewis*).

KOREA : Gensan, —.vi.1887 (*Leech*).

FORMOSA : (*Hobson*).

CHINA : Shanghai, Fo-Kien, Tinghai, —.vii.1899 ; Kwanhsien, 18.viii.1926 (*G. M. Frank*) ; Lui Shin Tze, Hupeh Province, —.viii.1912 (*C. S. Betton*).

MALAYAN PEN. : Kuala Lumpur, 1937 (*H. T. Pagden*) ; Malacca, one larva boring stem of paddy, 10.xii.1924, 29.xii.1924 (*G. H. Corbett* and *B. A. R. Gater*).

INDIA : Pusa, larva boring rice stem, 1.ii.1918 (*T. B. Fletcher*) ; 7.iii.1930 (*C. K. Samuel*).

Biological notes : The larva of this species bores into the stem of rice. Fletcher and Ghosh (1920) give a general account of its biology in India, and describe its immature stages under the name " Rice Chilo " (pp. 390–391, plates 57, 58). Its biology and ecology have been investigated in Japan (see *Chilo simplex* (Butler) by several workers. Harukawa, Takato and Kumashiro (1931) studied the effect of temperature on its development; hatching of eggs and the structure of the eyes were investigated by Maruma (1933) and Sugiyama (1933), respectively; Kaburaki and Iwasa (1933) studied its response to illumination; Yagi (1934) studied its nocturnal activity; Harukawa, Takato and Kamshiro (1931) worked on its population density.

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[2] In Japanese ; paper not seen.

Remarks: Hampson (1895, 1896) regarded *Chilo suppressalis* (Walker) and *Chilo simplex* (Butler) as distinct species. Fletcher (1928) in his final list of the Crambine borers does not mention any of these names. He, however, gave a new name, *Chilo oryzae*, to what he had previously called the "Rice Chilo." Kawada (1930) sank (from the description and figures) *Chilo oryzae* Fletcher as a synonym of *Chilo simplex*. Bisset (1939) sank the latter as a synonym of *Chilo suppressalis*. The present writer has examined the types of all these three, and confirms the synonymies proposed by Kawada and by Bisset.

Chilo zonellus (Swinhoe) (Pl. I, fig. 8; Pl. II, fig. 3; Pl. III, figs. 2, 8, 15).

Crambus zonellus Swinhoe, 1884 : 528.
Chilo zonellus (Swinhoe), Hampson, 1895 : 957. Fletcher, 1928 : 58. Bisset, 1939 : 47.
Crambus partellus Swinhoe, 1885 : 879.
Chilo partellus (Swinhoe), Hampson, 1895 : 957.

♂. Fore wing whitish brown to straw-coloured, with dark brown to piceous scales usually forming a streak on the costa; three rather diffuse spots on the disk and a shadowy band running from the apex towards the centre of hind margin but stopping half way; sometimes an additional, subterminal band present. Series of spots on termen small, usually entirely piceous or black; fringe slightly darker near base. In certain examples the entire pattern of the wing very faint. Hind wing very light straw colour. Frons (Pl. I, fig. 8) conical, with a distinct corneous point; ventral surface not flattened, but smooth and without a ridge. Labial palpi two and a half times the length of head, covered with dark brown to whitish scales.

♀. Usually much larger; fore wing much lighter in coloration than that of male, with the darker scales sparser and more diffuse; bands usually indistinct. Hind wing whitish.

Male genitalia.—Harpe (Pl. II, fig. 3) subtriangular; costa with a relatively heavily sclerotized, blunt, sub-basal projection which is slightly curved inward. Uncus triangular, with sides as long as the base; apex sharply pointed, and with a few sparse setae on the dorsal surface; gnathos similar, but without setae. Anellus (Pl. III, fig. 8) consisting of a large basal plate (which is a little longer than wide and is slightly bent) and a pair of lateral arms which are rather short, curved upward and forward to lie on either side of and a little above the aedeagus, each arm being enlarged at apex. Aedeagus (fig. 2) long, divided in the distal two-thirds into upper and lower parts, the former with a small keel in the middle and the latter with a shallow channel dorsally.

Female genitalia.—Genital opening with a chitinous shield (Pl. III, fig. 15) projecting from its lower margin, the shield broad, divided distally into two sub-rounded halves, which bear prominent but irregular, longitudinal wrinkles. Ductus bursae narrow, long, not heavily chitinized, signum present.

Expanse: ♂, 18–24 mm.; ♀, 22–30 mm.

Types: *C. zonellus* (♂, from Karachi) and *C. partellus* (♂, from Poona), in the British Museum.

Material examined: 28 males and 45 females from the following localities:

INDIA: Punjab: Mean Meer, Lahore, 1891 (*Harford*); Kangra valley, 4500 ft.; —.viii.1899 (*Dudgeon*); Campbellpur (*Yerbury*). Delhi: New Delhi, larva boring stem of *cholam* [*Sorghum vulgare*], 18.vii.1938, 5.viii.1938, 8.viii.1938 (*M. Ahamad*); larva boring maize 20.viii.1938 (*M. Ahamad*). United Provinces: Moghal Serai, 16.ix.1903 (*C. S. Betton*); Cawnpur, 3.x.1904 (*C. S. Betton*); on juar [*Andropogon sorghum*], 27.viii.1914, (*E. S. David*). Bihar: Pusa, in maize, 29.viii.1914, 2.ix.1914; on *juar*, 28.x.1914; young maize stem, 5.v.1917, 21.v.1917, 24.v.1917, 18.v.1917; causing "dead heart" in maize, 24.vii.1917, 27.vii.1917 (*R. S.*); 28.vi.1918, 1 ♀; in *juar* stem, 3.x.1918; 16.vi.1919; on maize, 8.viii.1923 (*Peries*); larva boring sugar-cane stem, 4.viii.1926 (*Haq*); at light, 13.ix.1933 (*H. N. Batra*); on maize, 24.vii.1935 (*Rangi*). Assam: Khasis, —.viii.1896. Sikhim: 2800 ft., —.vii.1895 (*J. G. Pilcher*), 1800 ft., —.vi.1896, —.vii.1897 (*G. C. Dudgeon*). Bombay: —.vii.1892 (*Davidson*). Poona: —.x.1882. Sindh: —.vii.1885. Madras: Nilgiris Hills, 1889 (*Hampson*); Coimbatore, larva boring maize stem, 24.ii.1933, 6.iii.1933, 12.iii.1934 (*J. E. K.*): larva boring *cholam* stem, 5.ii.1934, —.vi.1934 (*C. K. S.*); reared from maize stem, 7.ii.1938, 10.iii.1938 (*C. K. S.*); larvae boring stem of sorghum, 20.xii.1938 (*Venkataram*); larva boring sugar-cane, 26.iii.1940 (*Prakasam*).

CEYLON: Puttalam; Colombo, —.xi.1908; Kegalle, —.xi.1908 (*Mackwood*), —.x.1908 (*Alston*).

Biological notes: Detailed accounts of the biology of this species are given by Fletcher and Ghosh (1920, pp. 385–387, see account of "*Chilo simplex*") and Gupta (1940). The former workers list the following nine host-plants: Maize, "*juar*" (*Andropogon sorghum*), sugar-cane, rice, "*bajra*" (*Pennisetum typhoideum*), "*sama*" (*Panicum frumentaceum*), "*marua*" (*Eleusine coracana*), Sudan grass, Job's Tears (*Coix lachryma-jobi*). Of all the borers of graminaceous plants in India this species occurs in the largest numbers and is very widely distributed. It is a pest of maize, juar and rice; maize is mainly attacked when young, whereas juar is attacked in all stages; in rice it occurs throughout the season, but in greatest numbers in about October–November, when the plant develops ears. Gupta points out that sugar-cane is attacked mostly when it is grown in the neighbourhood of infested rice or maize fields. Descriptions of its earlier stages are given by the above-mentioned authors, and also by Isaac and Rao (1941) (larva) and Isaac and Venkatraman (1941) (pupa).

Remarks: Hampson (1895, 1896) regarded both *Crambus zonellus* and *Crambus partellus* as synonyms of *Chilo simplex* Butler. Fletcher (1928) considered *C. simplex* and *C. zonellus* as distinct species, *Chilo partellus* remaining synonymous with the latter. Kinoshita and Kawada (1932) also regarded *C. simplex* and *C. zonellus* as distinct species, but from their descriptions and figures it appears that what they regarded as *C. zonellus* is a different species, which the present writer is unable to identify from their figures.

Judging from the structure of the adult, particularly the female genitalia, *C. zonellus* appears to be very closely related to the following new species, *C. tamsi*, from South India.

Chilo tamsi sp. n. (Pl. III, fig. 14).

♀. Fore wing light, straw-coloured brown with very sparse and irregular sprinkling of brown to dark brown scales and with a small dark brown patch situated just outside the cell, between the bases of veins 5 and 6; the series of dark brown spots on the termen very small and oblong, the fringe being also of the same colour.

Frons similar in shape to that of *Chilo zonellus*; labial palpi about two and a half times the length of the head, covered with whitish and brown to dark brown scales. Ocelli, antennae and venation as described for the genus.

♂ unknown.

Female genitalia (Pl. III, fig. 14).—Similar to those of *C. zonellus* ; the genitalic shield (*s.*) heavily chitinized, but much narrower, nearly three times as long as wide, widely notched at the distal margin and without any well-defined longitudinal ridges ; an elongate and chitinized structure is attached to the base of and lies beneath the plate. (A similar structure is present in *zonellus* also, but it is very small and not as heavily chitinized.) Ductus bursae long and fairly narrow ; bursa large, oval, and with a distinct signum.

Expanse : ♀, 40 mm.

Biology : Unknown.

Type : A female from India, Travancore, Peermade (*Mrs. Imray*), in the British Museum.

Remarks : Closely related to *Chilo zonellus*, from which it can be separated by the larger size, coloration and the structure of the female genitalia, particularly that of the genital plate.

Chilo tumidicostalis (Hampson) (Pl. I, fig, 5 ; Pl. II, fig. 5 ; Pl. III, figs. 3, 9, 11).

Argyria tumidicostalis Hampson, 1919 : 448–449.
Chilo gemininotalis Hampson, 1919*a* : 59. Fletcher, 1928 : 59.

♂. Fore wing cinnamon brown, suffused with reddish to dark brown, with a rather diffuse dark brown fascia below the median nerve to a little beyond the cell, and a number of dark brown scales scattered irregularly all over except on the area immediately below the fascia and along the posterior margin. Termen with a series (usually seven) of black spots which are usually broken externally by small silvery-white points. Fringe rather shiny, light brown, and with a darker line at the base. Hind wings whitish, except for a few light brown scales in the costal area in males. Frons (Pl. I, fig. 5) widely conical, with a distinct corneous point at the apex and without any kind of flattened surface or ridge on the under surface. Labial palpi a little over twice the length of the head.

♀. Fore wing with a median fascia similar to that in the male but with the rest of the darker scales usually fewer. Hind wing whitish.

Male genitalia.—Harpe (Pl. II, fig. 5), quadrate ; costa straight, more heavily sclerotized and slightly dentate at apex. Uncus and gnathos (Pl. III, fig. 9) together beak-like, triangular, nearly as long as wide and pointed at apex; uncus with a number of short setae, gnathos slightly darker. Anellus (Pl. II, fig. 5) comprising a quadrate and slightly bent plate supporting the aedeagus, and a pair of long arms which are curved upward near the base and directed forward distally and lie along the sides of the aedeagus, each arm having a pair of sharp, conical teeth at the external margin, one of these teeth situated in the middle and the other at two-thirds the length of the arm. Aedeagus long, divided for the distal three-fourths of its length, the lower part slightly shorter and flattened into a bilobed structure, which is widely channelled to accommodate the upper part ; the latter is rather club-shaped and slightly narrowed in the middle and pointed at the apex, rather weakly chitinized dorsally and with a dense cluster of very short hairs in the subapical region.

Female genitalia.—Genital opening sunk in the oval membranous part of the sternite, its rim (Pl. III, fig. 11) provided with a heavily sclerotized band. The anterior half of ductus bursae heavily sclerotized at the sides, the posterior half only slightly chitinized. Bursa copulatrix sausage-like, three to four times as long as wide ; signum absent.

Expanse : ♂, 21–26 mm. ; ♀, 28–30 mm.

Types : *Argyria tumidicostalis* Hampson (♂, from Pabna, Bengal—not Patna as given in the original description), in the British Museum. *Chilo* *gemininotalis* Hampson (♀, from Kanny Koory, Cachar, Assam), also in the British Museum.

Material examined : 6 males and 3 females from the following localities :

ASSAM : Kany Koory, Cachar, —.vii.1907 ; Jorhart, sugar-cane, 23.viii.1918, 31.viii.1918, 1.ix.1918 (*S. R. Gupta*) ; boring stem of sugar-cane, 27.vi.1938 (*M. Ahamad*).

BENGAL : Pabna, larva in sugar-cane stem, 8.ix.1911.

Biological notes : This species is reported to feed exclusively on sugar-cane and the larvae, according to Fletcher and Ghosh (1920), occur in large numbers in individual plants, which are "literally riddled." They pupate inside the stem near previously made holes, through which the mature pupa wriggles out before the moth emerges. Descriptions of the larva and pupa are given by the above-mentioned writers, and by Isaac and Rao (1941) and Isaac and Venkatraman (1941).

Remarks : Differs from the other species of *Chilo* described above in that the frons is rather widely conical, the corneous point being directed antero-dorsally instead of anteriorly. In this character it represents an intermediate condition between *Chilo zonellus* and *Chilotraea auricilia* (Dudgeon). In the structure of the aedeagus, also, it resembles *C. auricilia*, from which, however, it may be easily separated by the venation of the fore wing, especially by veins 11 and 12, which are separate and not confluent as they are in *auricilia*. Further investigation in the field may throw more light on their relationship with one another.

Chilotraea gen. n.

Genotype : *Chilo infuscatellus* Snellen.

Referable to the subfamily CRAMBINAE ; allied to *Chilo* Zincken, from which it is readily distinguished by the structure of the frons and the confluence of veins 11 and 12 of the fore wing. Frons produced forward, subrounded, usually smooth and without a corneous point except in certain examples (of *C. auricilia* Dudgeon), which have a minute to very small, but not corneous, point at the apex. Ocelli present, well developed. Antennae in the male minutely serrate and ciliate, in the female setaceous. Proboscis poorly developed. Labial palpi porrect, covered with long scales and hairs, and two to three times as long as the head ; maxillary palpi triangularly dilated with scales. Fore wing with vein 3 arising from before the lower angle of the cell ; 4 and 5 separate at origin ; 6 from just below the upper angle (apex) of the cell and distinctly away from the middle of the latter ; 7 from the apex ; 8 and 9 stalked, arising a little away from 7 ; 10 from near the base of 8 and 9 ; 11 oblique, confluent with 12. Hind wing with veins 4 and 5 stalked ; 6 from the apex of the cell ; 7 and 8 stalked.

Male genitalia.—Vinculum subrounded or produced apically and V-shaped. Harpes broadly triangular to subquadrangular, undivided. Costa simple, the rest of the marginal area with rather dense and moderately long hairs. Tegumen triangular, nearly as long as broad at base, with the sides sclerotized. Uncus and gnathos also triangular, sharp and beak-like. Anellus consisting of a rather small plate with a pair of short to moderately long lateral arms which lie forward on either side of the aedeagus. Aedeagus club-shaped, sometimes with a short or moderately long process attached to underside near base.

Female genitalia.—Ovipositor normal (Pl. IV, fig. 5), moderately long. Ostium lightly chitinized, either surrounded (except at the extreme apex) by roughly chitinized area or covered by a heavily sclerotized plate. Ductus bursae long and narrow ; bursa copulatrix small, oval, with or without signum. Both the ductus and bursa poorly chitinized.

Range : India, Burma, Ceylon, Java, Formosa, Korea.

Remarks : Four species are included in this genus ; one of them is new, and the other three have been placed, at different times in the past, under *Chilo*, *Diatraea* or *Argyria*, to which they bear resemblance in one way or another. Detailed investigations based on the genotypes of these genera show that the species under discussion are not congeneric with any of them, and may at once be separated even on external characters from *Diatraea* and *Argyria*. The former is confined to the New World and is without ocelli, while the species now placed in *Chilotraea* possess a pair of ocelli ; this external difference is further supported by differences in the structure of the genitalia (see remarks on *Proceras*). The genus *Argyria* differs from *Chilotraea* in that it has a well developed proboscis (Pl. I, fig. 3), the frons is not produced forward and veins 11 and 12 of the fore wing are not confluent ; the genitalia are also characterized by important differences, and in *Argyria* the harpes are always divided (Pl. VII, fig. 12). As regards the genus *Chilo*, it has already been pointed out that it differs from *Chilotraea* in two important characters relating to the structure of the frons and the venation of the fore wing. There are, however, certain abnormalities and exceptions with regard to these characters in a small percentage of the material examined. That such exceptions exist in several other species of the subfamily is well known. Box (1931), noting abnormalities with regard to the confluence of vein 10 with 8 and 9 of the fore wing in *Diatraea*, gives the following figures :

D. saccharalis (Fabr.).—In 2 females among 126 males and 295 females.
D. luteella Box.—In 1 female among 1 male and 2 females.
D. entrerina Box.—In 3 females among 5 males and 54 females.

Abnormalities in the venation of the fore wing are shown by the following two species of *Chilotraea* :

C. infuscatellus (Snellen).—(*a*) Vein 11 missing (in one wing)—in 1 female ; (*b*) vein 11 separate from 12—in 2 males and 1 female among 15 males and 52 females.

C. ceylonicus (Hampson).—(*a*) Vein 11 separate from 12—in 1 female among 3 males and 6 females.

In none of the 104 examples of *C. auricilia* (Dudgeon) examined was any such case of abnormal venation observed. As pointed out earlier, its frons shows a certain amount of variation in that some of the examples have a minute to very small point (which is not corneous) at the apex. Nine males and 32 females showed this character among 50 examples of each sex.

Key to the Species of the Genus *Chilotraea*.

(a) *Based on coloration and size.*

1. Fore wing deep straw-coloured to light fuscous but without metallic spots ; usually with a pair of discoidal blackish spots (the lower one being defined on the outer side by white) and a subterminal pale fuscous line or a series of spots ; terminal series of black spots defined on inner side by minute white spots ; fringe matt, with two dark lines. (India, Burma, Java, Formosa, Korea, etc.) *infuscatellus* (Snellen).

Fore wing straw-coloured, irrorated with fuscous and fulvous, and with metallic spots; terminal series of black spots not defined on inner side by white; fringe shiny, with a single dark line . . . . . . 2.

2. Fore wing with fuscous irrorations, forming streaks in the interspaces between the veins, and with a light fulvous median line; terminal series of black spots large and with silvery white centres; fringe silvery . . . . 3.

Fore wing with fuscous irrorations not forming streaks but irregularly dispersed; without a fulvous median line; terminal series of black spots small, ill defined, and without silvery white centres; fringe golden. (India, Burma, Formosa, etc.) . . . . . *auricilia* (Dudgeon).

3. Expanse of male 12 mm., of female 17 mm. (India) . . . . *bandra* sp. n.

Expanse of male 20–22 mm., of female 24–28 mm. (Ceylon) *ceylonicus* (Hampson).

(b) *Based on genitalic characters.*

1. ♂. Aedeagus (Pl. IV, fig. 2) with a quadrate keel in the middle; anellus (fig. 3) with the lateral arms long, slender, subequal, and each with an oblong knob at apex. ♀. Genital opening covered by a strongly chitinized plate which is divided distally into a pair of triangular lobes (fig. 5) . . . . *infuscatellus* (Snellen).

♂. Aedeagus without a keel; anellus with the lateral arms stouter, when long either unequal in length or without knobs. ♀. Without a chitinized plate covering genital opening . . . . 2.

2. ♂. Aedeagus with a tongue-like process on the underside; lateral arms of anellus subequal, without knobs. ♀. Genital opening surrounded by sclerotized, subcircular, wrinkled area . . . . 3.

♂. Aedeagus (fig. 8) without the tongue-like process; lateral arms of anellus (fig. 9) unequal in length, each with blunt knob at apex. ♀. Genital opening (though itself sclerotized) not surrounded by wrinkled and sclerotized area (fig. 10) . . . . . *ceylonicus* (Hampson).

3. ♂. The lower process of aedeagus (Pl. V, fig. 9) short, slightly longer than wide, sub-rounded distally; anellus (fig. 7) with transverse basal plate, and long and pointed lateral arms. ♀. Base of ductus bursae not distinctly chitinized; signum present . . . . . *bandra* sp. n.

♂. The lower process of aedeagus (fig. 4) long, three to four times longer than wide, with a circular emargination distally; anellus (fig. 2) with a large oval basal plate, and short and blunt lateral arms. ♀. Base of ductus bursae (fig. 5) distinctly sclerotized, signum absent *auricilia* (Dudgeon).

Chilotraea infuscatellus (Snellen) (Pl. I, fig. 2; Pl. IV, figs. 1–5).

Chilo infuscatellus Snellen, 1890 : 94; 1891 : 347–349.
Argyria sticticraspis Hampson, 1919 : 449. Isaac, 1940 : 129–131. (Syn. n.)
Diatraea sticticraspis (Hampson), Isaac, 1937 : 175.
Argyria coniorta Hampson, 1919 : 449. Fletcher, 1928 : 58–59.
Diatraea calmina Hampson, 1919 : 544. (Syn. n.)
Diatraea shariinensis Eguchi, 1933 : 3, 19, pl. i. (Syn. n.)

♂. Head and thorax fuscous; antennae with dark and whitish-brown rings; palpi whitish mixed with fuscous. Fore wing deep straw-coloured to light fuscous, the latter especially along median vein and in and beyond the cell; usually with two blackish discoidal spots, the lower one being defined on outer side by white; a subterminal pale fuscous line or a series of spots usually present, sometimes mixed with whitish scales;

a terminal series of minute black spots defined on inner side by minute white spots; fringe straw-coloured with two darker lines. Hind wing whitish with the apical area, part of termen and base of fringe light buff.

Frons (Pl. I, fig. 2) produced forward, rounded, and without a trace of an apical point; labial palpi a little over twice the length of the head.

♀. Much larger than the male; coloration similar, but slightly lighter. Frons and palpi similar; antennae much narrower and rather setaceous.

Male genitalia.—Vinculum (Pl. IV, fig. 1) subrounded, not produced apically. Harpes subtriangular, subrounded and with rather dense hairs towards the apex; costa straight. Tegumen (fig. 4) triangular, as described for the genus. Uncus and gnathos similar, triangular, beak-like, short and sharply pointed at apex. Anellus (fig. 3) consisting of a subrounded and slightly bent plate, with the lateral arms long and slender, subequal in length, each with an oblong knob at apex. Aedeagus (fig. 2) elongate, about five times as long as wide, slightly curved downward, pointed at apex, with a subquadrate keel in the middle of the ventral surface and with a rather indistinct cornutus.

Female genitalia.—Genital opening covered by a strongly chitinized plate (fig. 5), which arises from the lower wall of the opening and is divided distally into a pair of triangular lobes which are visible externally; ductus bursae long and narrow; bursa copulatrix subglobular to oval, with a minute signum situated near the base, subquadrate in outline and with a diagonal fold which is deep in the centre.

Expanse: ♂, 20–26 mm.; ♀, 28–33 mm.

Types: *Chilo infuscatellus* Snellen (from Java) in Rijksmuseum van Natuurlijke Historie, Leiden. (No holotype was fixed by Snellen; the male example from his original material (co-types) which was figured is fortunately available, and has been marked as lectotype by the present writer.) *Argyria sticticraspis* Hampson (♀, from Coimbatore, Madras Province, S. India), *Argyria coniorta* Hampson (♂, from Pusa, Bihar, India) and *Diatraea calmina* Hampson (♀, from Kinyua, Burma), all in the British Museum.

Material examined: 18 males and 63 females from the following localities:

KOREA: Sharün, 30, 31.v.1929, 22, 26.vii. 1929 (*M. Eguchi*).

FORMOSA: Formosa (Taiwan) on sugar-cane, 19.iii.1931 (*H. E. Box*).

JAVA: Tegal, West Java, —.i.1889 (*Lucassen*); Pasoeroean, —.viii.1915.

BURMA: Kinyua, 23.ix.1900 (*Bingham*).

INDIA: Bihar: Pusa, larva in sugar-cane, 17, 28.viii.1914; larva boring stem of sugar-cane, 11, 28.viii.1926 (*Haq*); on sugar-cane, 24.vii.1929, 21.vi.1930, —.viii.1934 (*G. D. Ojha*); larva in sugar-cane, 27.iv.1933 (*H. N. Batra*); on sugar-cane, 14, 16.vi.1934 (*R. Saran*). Madras Province: Coimbatore, larva in sugar-cane, 4.viii.1912 (*T. B. Fletcher*); larva in sugar-cane shoot, —.xi.1934 (*C. K. Samuel*); larva boring stem of sugar-cane, 30.iii.1938, 4, 20.ix.1938, 9, 12.iv.1939, 18, 19.v.1939, 2, 6, 8, 9, 12, 19, 20.vi.1939, 5, 10, 24.vii.1939, 18.viii.1939, 11.ix.1939, 3.x.1939 (*Prakasam*); larva boring sugar-cane, 9, 10, 28.iii.1939, 8, 13.iv.1939, 2, 4, 5, 11, 18.v.1939 (*Venkatraman*); larva boring sugar-cane, 3, 9, 18.x.1939, 26.iv.1940, 9.v.1940, 17.vii.1940 (*R. M. Rao*).

Recorded as widely distributed in India.

Remarks: The systematic position and nomenclature of this species has been much confused in the past, as has been pointed out in the historical account. Examination of the genitalia of the type and other material from Java of *infuscatellus* leaves no doubt that it is the same as *Argyria sticticraspis* Hampson, described from India. Regarding *Diatraea calmina* Hampson, the type comes from Burma (and not Punjab, as recorded in the *Zoological Record*, 1919), and is a female which agrees with the female of *infuscatellus* in all structural details; the name *calmina* is therefore regarded as synonymous with the latter. There were seven other specimens (paratypes) mentioned by Hampson when he described *calmina*. All of these are also females; four of them have the same data as the type and agree with it structurally, but the remaining three, from Cawnpur, Moghal Serai and Pusa, are, in fact, *Chilo zonellus* Swinhoe. Six examples from Sharün, Korea, of *Diatraea shariinensis* Eguchi, as well as the figures given by Eguchi (1933), agree in structural details with *infuscatellus*; the two names are, therefore, regarded as synonymous.

Biological notes: Fletcher and Ghosh (1920) (see also Fletcher, 1928) recorded the following food-plants: Sugar-cane, *juar* (*Andropogon sorghum*), *rarhi* and *batri* (*Saccharum spontaneum*), *ikri* (*Saccharum fuscum*) and Jove grass (*Rottboellia compressa*). It is a serious pest of sugar-cane, and commences its attack from the time the crop is young. Pruthi and Naryanan (1939), while estimating the loss caused by borers and termites to mature sugar-cane at Pusa in 1935 and 1936, reported that 80–85 per cent. of the population of stem-borers comprised this species. Its seasonal history varies considerably in different parts of India. The pupa possesses an excellent diagnostic character in that its abdominal segments have flattened, wavy ridges which almost touch one another. The larva and pupa have been described by Eguchi (1933), Isaac and Rao (1941), and Isaac and Venkatraman (1941). Eguchi (1933) records this species as a pest of Italian millet in Korea, where it also attacks *Andropogon sorghum*, *Panicum miliaceum*, *P. frumentaceum* and *Zea mays*; notes on its biology and natural enemies are given in Japanese with a short summary in English. Certain aspects of its ecology and biological control in Formosa are dealt with by Takahashi (1938) and Takano (1937).

Chilotraea ceylonicus (Hampson) (Pl. IV, figs. 6–11).

Chilo ceylonicus Hampson, 1895 : 957.

♂. Head, palpi and thorax straw-coloured, mixed with fuscous; antennae with dark and whitish-brown rings. Fore wing straw-coloured with fuscous irrorations, tending to form streaks in the interspaces except on the inner margin, and a pair of discal spots, one of which is at the base of vein 5 and the other below that of vein 3. An indistinct fulvous medial line curved below costa and with a few silvery scales on its edges; a subterminal silvery line bent inward below costa, faintly margined by fulvous; series of terminal spots large, black with silver-white centres; fringe rather silvery, with a darker streak at the base. Hind wing tinged with light buff to fuscous except near base, which is whitish; termen with darker patches.

Frons (Pl. IV, fig. 6) produced forward, subrounded and without any trace of an apical conical point. Labial palpi about twice the length of the head; antennae, ocelli, etc., as described for the genus.

♀, Larger than the male, with similar coloration except the hind wings, which are whitish with light buff termen.

Male genitalia.—Vinculum similar to that of *C. infuscatellus*. Harpes (fig. 7) subquadrate, slightly narrowed and subrounded apically. Costa straight, with short and sparse hairs, the other margins with relatively longer and denser hairs. Tegumen, uncus and gnathos (fig. 11) as in *infuscatellus*. Anellus (fig. 9) with subrounded and slightly bent basal plate and a pair of lateral arms, which are distinctly unequal in length, stouter than those of *infuscatellus*, and each with a rather differently shaped, blunt knob at apex.

Aedeagus (fig. 8) club-shaped, slightly curved and narrow in the middle and pointed towards the apex, with a cornutus.

Female genitalia.—Genital opening (fig. 10, *o.*) transverse oval, with the ventral wall sclerotized, forming rather indistinct, short and longitudinal ridges. Ductus bursae long and narrow. Bursa copulatrix oval, with the signum situated a little before the middle, ill defined and with a fold in the middle.

Expanse : ♂, 20–22 mm. ; ♀, 24–28 mm.

Type : A male (from Ceylon) in the British Museum.

Material examined : 3 males and 6 females from the following localities :

CEYLON : Hambantota (*Pole*) ; W. Hapusale, —.xi.1902, Gampola, —.vi.1903, —.iii.1905 ; Madulsima, —.x.1905, —.iii.1906 (*Mackwood*) ; exact locality not mentioned, 1892 (*Doncaster*).

Remarks : This species comes close to *C. infuscatellus* on account of the shape of the frons and structure of the male genitalia, but differs greatly in general coloration and the structure of the female genitalia. Nothing is known of the biology or early stages. It is closely allied to the following species in coloration and general structure, but the two differ greatly in size.

Chilotraea bandra sp. n. (Pl. V, figs. 6–10).

♂. Head and thorax light straw-coloured, palpi mixed with brown, antennae with white and brown rings. Fore wing of light straw-colour, with rather pale fuscous scales near the base of costa, and between the veins, forming rather narrow streaks of unequal length ; in addition, there is a small patch of fuscous, sometimes with a silvery lustre, situated a little below the base of vein 3 ; a light fulvous medial line curved (parallel to termen) below costa ; a subterminal silvery line, bent inward below costa and margined on either side by light fulvous scales ; series of terminal spots black to piceous with silvery white centres ; fringe greyish with fuscous line near base. Hind wing mostly whitish with light straw-colour near apex.

Frons moderately produced forward and subrounded ; labial palpi about twice as long as head ; antennae and ocelli as in the preceding species.

♀. Larger, similar to the male in coloration, etc.

Male genitalia.—Vinculum subrounded, not produced apically. Harpe (Pl. V, fig. 6) subtriangular, rounded at apex, with dense hairs on the margins except the costa, which is straight for the most part, but sharply curved near the base. Tegumen, uncus and gnathos (fig. 8) as in the preceding species. Anellus (fig. 7) comparatively large, consisting of a transverse-oval plate and a pair of rather stout and tapering arms which curve upward near the base and forward distally, so as to lie on either side of or over the aedeagus. Aedeagus (fig. 9) club-shaped, pointed at apex, and with a short tongue-like process (*p.*) on the lower surface and at two-thirds its length ; the process rests on the plate of the anellus, is slightly longer than wide and subrounded distally.

Female genitalia.—Genital opening (fig. 10) surrounded by a small area which is moderately sclerotized and rough in appearance ; ductus bursae long ; bursa copulatrix oval, and with a small signum.

Expanse : ♂, 12 mm. ; ♀, 17 mm.

Type : A male, from INDIA (Bandra, Bombay, 20.vi.1902) ; in the British Museum.

Paratypes : A male with the same data and a female from the same locality as the type—both in the British Museum.

Remarks : Nothing is known of its biology. Allied to *C. ceylonicus* in coloration and general structure, but much smaller ; easily distinguishable from *ceylonicus* by the structure of the genitalia, particularly of the male.

Chilotraea auricilia (Dudgeon) (Pl. V, figs. 1–5).

Chilo auricilia Dudgeon, 1905 : 405.
Diatraea auricilia (Dudgeon) Fletcher, 1928 : 58.

♂. Head and thorax straw-coloured, sometimes irrorated with fuscous; antennae with dark and whitish-brown rings; palpi irrorated with fuscous. Fore wing very variable in coloration; that of the type is as follows: Straw-coloured, irrorated with fuscous; a dark metallic spot in the cell, another at the origin of vein 4 and 5, one rather oblong below the origin of vein 3 and extending a little below vein 2; a few metallic scales in and beyond the cell; a subterminal series of darker, mostly metallic spots incurved towards the costa; a terminal series of black spots rather small and ill-defined; fringe golden, with a dark streak along the base. Hind wing light straw-coloured; fringe rather silvery. In another example (from Pusa, Bihar) the fuscous scales are more numerous all over the fore wing, and instead of forming various spots in and below the cell as described above, they tend to form a medial line which runs almost parallel to the subterminal series of spots; the terminal series of spots large and almost black. In several other examples the fore wings are either ochreous irrorated with brown or almost pale fuscous; in either case the discal and subterminal series of spots are poorly developed.

Frons produced forward, subrounded, and usually smooth at apex; sometimes the latter with a minute conical point which is not corneous. Labial palpi about twice the length of the head; antennae, ocelli, etc., as in other species of the genus; venation of fore wing constant.

♀. Usually larger than the male. Fore wing as variable in coloration as in male, but ground-colour usually lighter and metallic spots smaller, when present; hind wing similar to that of male. Frons produced forward, subrounded and mostly with a minute conical point (not corneous) at apex, sometimes uniformly smooth. Labial palpi about twice the length of the head. Antennae thinner than those of the male. Ocelli, venation, etc., as described for the genus.

Male genitalia.—Vinculum (Pl. V, fig. 1) produced apically and **U**-shaped, but with the apex subrounded. Harpe subquadrangular, slightly narrowed a little before the apex. Costa straight, hairs moderately long and sparse except towards the apex. Tegumen (fig. 3), uncus and gnathos as in other species of the genus. Anellus (fig. 2) consisting of a well developed, oval and considerably bent basal plate with relatively short lateral arms, which are blunt at apices and are directed forward to lie on either side of and almost over the aedeagus. Aedeagus (fig. 4) divided, the upper part moderately long, gradually narrowed and pointed at apex except for a short conical projection, on the dorsal aspect, at two-thirds its length; the lower part like a long tongue (3–4 times longer than its width) arising from near base of aedeagus and with a deep rounded emargination at apex.

Female genitalia.—Genital opening (fig. 5) sclerotized, surrounded by sclerotized, subcircular area which is wrinkled and finely dentate at the margin towards the opening; ductus bursae very narrow, and long; bursa copulatrix subrounded, signum absent.

Expanse : ♂, 18–25 mm.; ♀, 23–30 mm.

Type : A male (from Burogah) in the British Museum.

Material examined : 56 males and 60 females from the following localities :

India : Bihar : Burogah (North Bihar), larva boring sugar-cane (*MacKenzie*); Pusa, larva boring sugar-cane stem, 16–19, 24.ii.1926, 1, 5, 15.iii.1926 (*Ojha*), 22.iv.1926 (*Chaterji*); on sugar-cane, 18, 21.ii.1930, 1, 5, 7.iii.1930 (*Gupta*); 22.ii.1934, 5, 26.iii.1934 (*E. S. N.*); 11.ii.1935, light-trap, 6.45–9 p.m., 26.ii.1935 (*E. J. Vevai*); 11, 15, 26, 27.ii.1935, reared, pupated 10.iii emerged 28.iii.1935, on sugar-cane, —.iii.1936 (*N. Ayyar*); larva boring stem of sugar-cane, 4.viii, 9, 11.ix, 9, 12.x.1937 (*E. Hassan*); 4, 6, 11.iii.1938 (*M. S. Anwar*). United Provinces: Gorakhpur, larva boring stem of sugar-cane 22.ii, 8.iii.1940 (*V. P. Rao*). Assam, Sikkim, Bhutan: Naga Hills, 5500–7000 ft., —.ix–x.1889 (*W. Doherty*); Sikkim, 4000 ft., —.ix.1895 (*J. G. Pilcher*); Bhutan, —.ix.1894, 1895 (*Dudgeon*).

CEYLON: Colombo, —.viii.1908 (*Mackwood*) (this record is based on a single female example and should be accepted with some caution until some males are obtained in Ceylon).

Also recorded from Burma (Ghosh, 1924) and Formosa (Ijima, 1936).

Remarks: Hampson (1912) synonymized *Chilo auricilia* with *Chilo suppressalis* Walker. Although, in 1917, Fletcher followed the above-mentioned synonymy, in 1918 he regarded *auricilia* as a distinct species. In 1928, however, he stated that what he had been previously calling *auricilia* was in fact *Argyria sticticraspis* Hampson, and that the account for the species designated by him as *Diatraea* sp. (C.S. 1674) was true *auricilia*, which he continued to regard as a species of *Diatraea* and not of *Chilo*, as originally proposed by Dudgeon. As the generic name *Diatraea* Guilding is being confined to the New World species (see remarks on the genus *Proceras*), this species cannot be placed under that genus. It is apparently closely related to the genus *Chilo*, but differs from it in the important character of the veins 11 and 12 of the fore wing being confluent, and also, to a certain extent, in the shape of the frons. Hence it is placed in the genus *Chilotraea*, within which it comes close to *C. bandra* on the characters of the genitalia.

Biological notes: Fletcher and Ghosh (1920, see also Fletcher, 1928) recorded this species from sugar-cane and rice in Bihar, Bengal and Assam. Ghosh (1924) recorded it from rice in Burma (see his notes on *Diatraea* sp., C.S. No. 1674, and not on what was there called *Diatraea auricilia*). In 1936 Ijima recorded it as a pest of rice in Formosa. Although at first Corbett (1937) recorded *auricilia* and *Diatraea polychrysa* Meyrick as stem borers of rice in Malaya, he and Pagden (1941) pointed out that the species actually involved were *C. suppressalis* and *polychrysa*. The present writer has not so far seen any example of this species bred from rice in India or elsewhere. Its early stages have also been dealt with by Fletcher and Ghosh, Gupta (1940), Isaac and Rao (1941) and Isaac and Venkatraman (1941).

Drasa gen. n.

Genotype: *Diatraea cashmirensis* Hampson, 1919: 543.

Referable to the subfamily CRAMBINAE. Frons distinctly produced forward, conical, pointed and corneous at apex. Ocelli present, well developed. Antennae in the male rather thin, setaceous, minutely serrate and with mostly elongate segments. Labium rather poorly developed. Maxillary palpi short, triangularly dilated with scales; labial palpi also short, nearly equal to length of head, porrect. Fore wing rather narrow; vein 3 arising almost from lower angle of cell; 4 and 5 distinctly stalked; 6 from just below the upper angle (apex); 7 from apex; 8 and 9 stalked, arising a little away from 7, both reaching costa, 9 very short and arising at two-thirds the length of 8 and making an angle of about 75° with it; 10 arising a little away from the base of 8 and 9; 11 oblique, confluent with 12, which runs very close to the costal margin. Hind wing with vein 3 very close to the lower angle of the cell; 4 and 5 with a distinct stalk; 6 arising from upper angle of cell; 7 arising fairly close to 6, but coincident with 8 for some distance.

Male genitalia.—Vinculum very much reduced (Pl. VII, fig. 4). Harpes undivided, ovate.

Costa simple. Tegumen (fig. 6) triangular, without lateral projection. Uncus and gnathos moderately developed, beak-like, subtriangular but exactly similar, each with pointed apex. Anellus small, disk-like. Aedeagus (fig. 5) short, tubular. (Since only one species of the genus is known, these genitalic characters are provisional.)

Female not known.

Range : Kashmir, North India.

Remarks : Distinguishable from the other genera considered in this paper by veins 4 and 5 being distinctly stalked in the fore wing ; also by vein 8 reaching the costal margin and vein 9 being very short, and almost perpendicular to 8. It further differs from all other genera (namely *Coniesta*, *Girdharia* and *Chilotraea*) that have the frons conical and veins 11 and 12 of the fore wing confluent in that the labial palpi are short. In the structure of the male genitalia it differs from *Coniesta* and *Girdharia* in several respects, particularly in that the harpes are undivided. Although in the latter character as well as those of uncus and gnathos it resembles *Chilotraea*, the two differ greatly in the structure of vinculum, anellus and aedeagus.

Drasa cashmirensis (Hampson) Pl. VII, figs. 4–6).

Diatraea cashmirensis Hampson, 1919*b* : 543.

♂. Head and thorax ochreous brown. Frons and patagia, except on outer side towards base, white. Abdomen ochreous white, dorsally suffused with reddish-brown towards base, palpi ochreous suffused with white. Fore wing straw-coloured, irrorated with fuscous scales tending to form rather thick streaks in the interspaces ; traces of silvery subterminal line ; a terminal series of fuscous spots. Hind wing whitish tinged with pale brown, fringe white.

Male genitalia.—Vinculum (fig. 4,v.) poorly developed, subrounded. Harpes (fig. 4) undivided, ovate. Costa simple, apex rounded ; hairs moderately long and dense along the external margin. Tegumen (fig. 6) triangular, almost uniformly chitinized. Uncus subtriangular, longer than the width at the base, with a few long setae on the lateral margin. Apex pointed but not as sharp as that of gnathos, which is otherwise similar to uncus in outline, and is without setae. Anellus (A) subcircular with a small emargination anteriorly. Aedeagus (fig. 5) almost uniformly tubular, less than the length of a harpe, less strongly chitinized at the apex ; cornutus absent.

♀. Unknown.

Type : A male (from Dras, Kashmir), in the British Museum (Natural History).

Biology: Unknown.

Proceras Bojer (Pl. VI, figs. 1–13).

Proceras Bojer, 1856, (4 plates), 1873 : 158. Tams, 1942 : 67–68.
Borer Guenée *in* Maillard, 1862 : G70. Tams, 1942 : 67.
Genotype : *Proceras sacchariphagus* Bojer (1856).

Referable to the subfamily CRAMBINAE. Frons (Pl. I, fig. 6) not produced forward, broadly rounded to rather flat. Ocelli absent. Antennae in male minutely serrate and ciliate, in female setaceous. Proboscis poorly developed. Labial palpi porrect, slightly curved downward distally, long, about three times the length of the head ; maxillary palpi triangularly dilated with scales. Fore wing with vein 3 arising before lower angle of cell, 4 and 5 separate at origin, 6 below apex of cell, 7 at apex, 8 and 9 stalked, 10 arising away from 8 and 9, 11 anastomosing with 12. Hind wing with vein 4 and 5 stalked, 6 from upper angle of cell, 7 and 8 stalked.

Male genitalia (Pl. VI).—Vinculum (figs. 1, 3, 4, 6) variously shaped, sharply pointed, subrounded or truncate. Harpe undivided, rather broadly oval. Costal margin straight, relatively more heavily sclerotized and devoid of hairs, the other margins with moderate to rather dense hairs. Tegumen mainly tubular (fig. 5), as long as the harpe, sclerotized except a small area at the base, without a basal or lateral lobe. Uncus and gnathos triangular, short, beak-like, with rather pointed apices. Anellus (fig. 2) consisting of a rather small, subrounded plate which is deeply notched anteriorly. Aedeagus broadly tubular with oblique opening, the apical part heavily chitinized and lancet-like; cornuti well developed.

Female genitalia.—Genital opening with a sclerotized band (figs. 12, 13). Ductus bursae short, rather heavily sclerotized. Bursa copulatrix fairly large, oval to elongate and chitinized, signum absent.

Range: Mauritius, India, Ceylon, East Indies, Borneo, China, Japan, etc.

Remarks: Tams (1942), while proposing the revival of the generic name *Proceras* Bojer (1856) for the Old World species previously placed in the genus *Diatraea* Guilding (1828), stated: "Although the venation of the Old World moths of this group appears identical with that of the New World species, the structure of both male and female genitalia indicates that the Old World species belong to a genus different from that which bears the name *Diatraea* Guilding, of which the type is the New World *Diatraea saccharalis*, Fabr. . . . The first appearance under any name of an Old World species of Crambid Sugar-cane Borer is shown by the 1856 reference to *Proceras sacchariphagus* Bojer." Tams regarded the latter as the earliest valid name for the sugar-cane borer of Mauritius. Besides the venation, there are several other morphological characters which are common to the genera *Diatraea* and *Proceras*. Important among these are the general shape and coloration of the wings, the long labial palpi and the absence of ocelli. The shape of the frons, though different in various species of *Diatraea*, is not the same as in the known species of *Proceras*. In the genotype of the former (Pl. I, fig. 4) it is more rounded and produced forward, while in the latter it is subrounded and rather flattened and not produced forward (Pl. I, fig. 6). As regards the differences in the genitalia of the two genera, nothing has been mentioned by the earlier workers. Owing to the great variety in genitalic structure shown in the genus *Diatraea*, and to the fact that very little is known of the Old World species of *Proceras* and the related genera, it is difficult to generalize on such differences in structure as may be observed in the genotypes of the two genera. However, the following differences in their genitalic structure may be found to hold good in general. The harpes in *Diatraea* (Pl. VII, fig. 1) are elongate, much narrowed distally and with a sclerotized basal or sub-basal projection on the costa, while in *Proceras* (Pl. VI) they are relatively short, broadly oval and without any projection on the costa (figs. 1, 3, 4, 6). The tegumen in *Diatraea* often has basal or sub-basal lateral lobes (Pl. VII, fig. 2), while in *Proceras* it is tubular and without the lateral lobes. The aedeagus (fig. 3) is smaller in *Diatraea*, and its cornuti are not so well developed as in *Proceras*. Regarding the female genitalia, whereas the ductus bursae is short and bursa copulatrix large in both genera, in *Diatraea* the bursa alone is chitinized (except in *D. strigipennella* Dyar) at the junction with the ductus (Pl. X, fig. 5), while in *Proceras* both the ductus and bursa are chitinized (Pl. VI, figs. 12, 13).

Key to the Species of the Genus *Proceras*.

Based on characters of the male genitalia (Pl. VI).

1. Aedeagus (fig. 7) with two ranks of short cornuti ; vinculum broad at base (fig. 3), very narrowed in distal half and pointed at apex. (India) . . . . *indicus* sp. n.
   Aedeagus with a single rank of cornuti ; vinculum sub-rounded at apex 2.
2. Aedeagus (figs. 8, 10) with short spines (*s.*) at lower part of the oblique opening, and with upper part in the form of a broad lancet (*l.*), which is asymmetrical and rather curved on one side ; rank of cornuti about two-thirds the length of aedeagus ; vinculum (fig. 1) broadly conical, sub-rounded at apex. (Borneo, Malaya, China, Formosa) *venosatus* (Walker).
   Aedeagus (fig. 9) without spines at the opening, with the lancet-like part very narrow and almost symmetrical ; rank of cornuti half the length of aedeagus ; vinculum (fig. 4) longer, much drawn out from the base, to a rather narrow, sub-rounded apex. (Mauritius, Madagascar, Java) . . . . *sacchariphagus* (Bojer).

Proceras sacchariphagus Bojer (Pl. VI, figs. 2, 4, 9, 11).

Proceras sacchariphagus Bojer, 1856. Bojer, 1873 : 158, 302, 432, 44 7, 534. Tams, 1942 : 67–68.
Borer saccharellus Guénee (*not* Fabricius), 1862 : G70. Tams, 1942 : 67–68.
Chilo mauriciellus Walker, 1863 : 141.
Diatraea mauriciella (Walker), Hampson, 1895 : 953. Vinson, 1941 : 148-153 ; 1942, 39–65.
Diatraea striatalis Snellen, 1890–1891 : 349. Hampson, 1895 : 954. Vinson, 1942 : 148–153 ; 1942 : 40.

♂. Fore wing pale ochreous to pinkish buff with dark brown to cinereous scales. Streaks on and between the veins and usually two dark spots, one of which is at the bases of veins 4 and 5 and the other, slightly fainter, near the base of vein 6. The series of small, dark spots along the termen more distinct in male than in female ; the fringe darker along the basal half. Hind wings slightly lighter than fore wings, especially near base ; suffused with light to dark brown towards costa and termen.

♀. Larger, with fore wing more acute at apex than in male ; coloration lighter, and usually with faint spots, if any, on the disk. Hind wing whitish.

Male genitalia.—Vinculum V-shaped, distinctly drawn out from the base to a narrow subrounded apex (Pl. VI, fig. 4). Harpes broadly suboval. Costa simple, moderately long hairs present on the apical margin ; elsewhere the hairs short and sparse. Tegumen, uncus and gnathos as described for the genus. Anellus (fig. 2) subrounded, emarginate anteriorly, the apex of the notch near the centre of anellus very narrow, but the distal part very broad. Aedeagus tubular, nearly four times as long as wide, with an oblique opening, the dorsal rim of which has a minutely rough surface ; when viewed from below the left half of the ventral part near the opening heavily sclerotized into a narrow, acutely triangular and almost symmetrical, blade-like structure with a rather smooth surface ; the remaining half is membranous ; rank of cornuti easily retractable, nearly half as long as the aedeagus, heavily sclerotized, spiky in appearance, like a young pine shoot.

Female genitalia (fig. 11).—Genital opening heavily sclerotized in a band ventrally ; ductus bursae short, slightly convoluted, heavily sclerotized, with longitudinal ridges ; bursa oblong-oval, sclerotized (becoming less so towards the apex), and with a few widely placed, and oblique folds.

Expanse : ♂, 25–28 mm. ; ♀, 30–34 mm.

Types : *Chilo mauriciellus* Walker (from Mauritius), in the British Museum ; *Diatraea striatalis* Snellen (from Java), in Rijksmuseum van Naturlijke Historie, Leiden (♂ made lectotype by the present writer). The types of *P. sacchariphagus* Bojer (from Mauritius) and *Borer saccharellus* Guénee (from Mauritius) are not known.

Material examined : 7 males and 5 females from the following localities :

MAURITIUS : Exact locality not given (*Beke*) ; La Baraque, —.xii.1930, 9.ii.1932 ; 13.ii.1932 : Belle Vue Hazel, ex. sugar-cane, —.x. 1938 (*J. Vinson*).

MADAGASCAR : Nossi Bé, 29.iv.1940 (*L. P. Regnard*).

JAVA : Jegal, —.ii.1889.(*Lucassen*).

Biological notes : The species is a pest of sugar-cane in Mauritius, where it seems to have been introduced from Java (see Vinson, 1942). Moutia (1934) deals with its biology in Mauritius, and considers this species to be responsible for an average loss of 15 per cent. of the crop.

Remarks : The type of *Proceras sacchariphagus* Bojer is apparently unknown, but there seems no doubt that Bojer referred to the same species as that to which the above-mentioned material from Mauritius belongs, since no other related species occurs as a pest of sugar-cane in that island. As to whether the Javanese examples (hitherto known as *D. striatalis* Snellen) form a separate subspecies, as has been tentatively suggested by Vinson (1941, 1942), the present writer is unable to give any opinion owing to the scanty material from Java that has been available for the present study. The question of their status requires further investigation, and is closely linked up with that of the related species occurring in Borneo (Sarawak being the type locality of *P. venosatus* Walker), Malaya, China, India, etc.

Hampson (1895) considered the species from Mauritius (under the name *D. mauriciella*) to be distinct from the Javanese *D. striatalis*, which he regarded as synonymous with " *D. venosata* " from Borneo. Later these three names were regarded as synonymous, though doubts were expressed by Fletcher (1918) as to the correctness of this step. In 1942 Vinson sank *striatalis* as a synonym of *mauriciella*, which he regarded as distinct from *venosatus* from India, although the type locality of the latter species is North Borneo. No comparison seems to have been made by him between the Bornean, Javanese and Mauritian material.

Proceras venosatus (Walker) (Pl. VI, figs. 1, 5, 6, 8, 10, 12).

Chilo venosatus Walker, 1863 : 144.
Diatraea venosata (Walker), Hampson, 1895 : 954.

Similar to *Proceras sacchariphagus* Bojer in external structure, size and coloration, but different in the structure of the genitalia.

Male genitalia.—Vinculum (Pl. VI, fig. 1) broadly conical, with a rounded apex. Harpes broadly suboval. Costa simple ; moderately long hairs present towards the apex (mostly rubbed off in material photographed) ; elsewhere the hairs sparser. Tegumen, gnathos and uncus as described for the genus. Anellus subrounded, with a rather narrow conical emargination reaching as far as the centre of anellus. Aedeagus (fig. 8, 10) broadly tubular, about three times as long as wide, with an oblique opening, the dorsal part of the rim of the latter provided with rather distinct spinous processes (*s.*), which vary slightly in dimensions in different examples. The elongate lancet-like structure (*l.*) on the ventral part better developed than in *sacchariphagus*, longer and slightly broader, conical, asymmetrical, one margin straight and the other slightly curved, surface slightly rough. Rank of cornuti nearly two-thirds the length of aedeagus, heavily sclerotized and spiky in appearance.

Attention may here be drawn to what are regarded provisionally as aberrations in two examples, from Ichang Gorge (China) and Malaya, in which the vinculum is truncate (fig. 6) and not broadly conical at apex. These examples show no other difference in structure.

Female genitalia.—Similar to those of *sacchariphagus*, but with the longitudinal ridges of the ductus bursae very faint.

Expanse : ♂, 25–27 mm. ; ♀, 28–30 mm.

Type : In the British Museum (from Sarawak ; a male with apex of abdomen broken).

Material examined : 10 males and 7 females from the following localities :

NORTH BORNEO : Sarawak (*Saunders' Coll.*).

MALAYAN PEN. : Singapore (*H. N. Ridley*) ; Perak, —.iii.1931.

CHINA : Ichang Gorge, —.viii.1887 (*Leech*) ; Shantung, Tsinan, 21.vi.1926 (*E. Hindle*).

FORMOSA : Kanshirei, 1000 ft., 12.ix.1907, 9.iv.1908 (*A. E. Wileman*) ; on sugar-cane, 27.iii.1931 (*H. E. Box*).

Biological notes : This species causes considerable damage to sugar-cane in Formosa and China. Takano (1934, 1937, 1940) and Takahashi (1938) give brief accounts of its natural enemies and biology in Formosa.

Remarks : The type, which is, in fact, the only specimen from Sarawak, Borneo, in the British Museum, is without the abdomen (and was probably so when Walker first described it, because a question mark follows his note on the length of the abdomen), with the result that information regarding its genitalia is entirely lacking. Until more material from Sarawak is known, any definition of *venosatus* must be regarded as provisional. The material from Malaya, China and Formosa, which shows considerable uniformity in the genitalic structure, is regarded by the present writer as belonging to *venosatus*, and this view is taken in the hope that it will cause less confusion in the literature than any other. Should a subsequent examination of the Bornean material prove it to be different from that from Malaya and elsewhere a new name can then be proposed for the latter.

Proceras indicus sp. n. (Pl. VI, figs. 3, 7, 13).

Similar to *Proceras sacchariphagus* Bojer in external structure, size and coloration, except that there is only one discal spot on the fore wing instead of the two that are usually present in *sacchariphagus* and *venosatus* ; differs also in the structure of the genitalia, and may be distinguished from the two above-mentioned species by the following characters.

Male genitalia.—Vinculum broad at the base, very much narrowed in the distal half and pointed at apex (fig. 3). Harpes broadly suboval, costa simple. Moderately long and rather dense hairs present towards the apex and on the lower margin, elsewhere the hairs sparser. Tegumen, gnathos and uncus as in other species of the genus. Anellus subrounded ; with an oblong emargination extending from the centre to the anterior margin. Aedeagus (fig. 7) similar to that of *venosatus* in general outline, but with denser and shorter spines on lower part of rim of the oblique opening and with two ranks of cornuti instead of the single one present in *venosatus* ; the two ranks of cornuti unequal in size, the larger one nearly as thick as that of *venosatus*, but much shorter, the smaller one nearly half the length and thickness of the larger one.

Female genitalia(fig. 13).—Similar to those of *venosatus*, but with the bursa more heavily chitinized and with distinct oblique ridges.

Expanse : ♂, 25–27 mm. ; ♀, 32–37 mm.

Type : A male, in the British Museum (Natural History) ; from INDIA—Pusa (Bihar)—on sugar-cane, 15.v.1914 (*R. S.*).

Paratypes : 3 males and 11 females ; in the British Museum and the Indian Museum, Calcutta, with the data as follows :

All from INDIA : Assam : Sibsagar, 24.ix.1911 (*H. M. Parish*). Bihar : Pusa, on sugar-cane, 25.viii.1914, 25.viii.1917. Madras Province : Coimbatore, boring internodes of sugar-cane, 11, 14.x.1938, 31.i.1939, 6.ii.1939, 9.iv.1939, 15.v.1939, 30.vi.1939, 12.xii.1939 (*Prakasam*), 21.xi.1938, 3.xii.1938, 2.i.1939 (*Venkatraman*), 3.x.1939 (*R. M. Rao*).

Biological notes : This species has hitherto been confused with and referred to as *Diatraea venosata* (Walker) in literature on Indian entomology. Fletcher and Ghosh (1920) give the following list of its food-plants : Sugar-cane, sudan grass, *Saccharum spontaneum* (*Rarhi* and *batri*), *Andropogon sorghum* (*juar*), *Saccharum fuscum* (*ikri*), *Pennisetum typhoideum* (*bajra*). They further pointed out that in the vicinity of Pusa the larvae occur largely in *batri*, Sudan grass and *juar*, and only occasionally in other plants, and regarded the species as a " real pest " of *juar* among the cultivated crops. Ghosh (1921) found it to be a " regular pest " of sugar-cane at Cuttack (Orissa). Isaac (1940) found it in " abundance " in sugar-cane at Coimbatore in South India. Pruthi and Naryanan (1939), while estimating the loss caused by borers and termites to mature sugar-cane at Pusa in 1935 and 1936, observed that this species formed 12 per cent. of the population of stem-borers in the canes examined. During the period it is absent from sugar-cane it occurs freely, according to Gupta (1940), in *ikri* and *batri*. Its status as a pest of cultivated cereals like *juar*, and of sugar-cane, may be important, and requires further investigation. The two other closely related species, namely, *P. sacchariphagus* and *P. venosatus*, cause considerable damage to sugar-cane in Mauritius, Java and Formosa.

Remarks : That the Indian species was different from that occurring in Mauritius and Java was recognized by Vinson (1942), but he continued to regard the former as " *D. venosata* Walker," in spite of the fact that the type locality of the latter is Sarawak, North Borneo. As shown above, the Indian material differs in important structural details from that coming from Malaya, China and Formosa. On geographical grounds it does not seem likely that the Bornean species, namely *venosata*, would be the same as the Indian, and that a distinct species would occur between the two, i.e in Malaya. On the other hand, it seems more likely that the Bornean species is the same as the one from Malaya, etc., and that the Indian species is at least as distinct from the latter as is the Javanese and Mauritian one. Consequently, a new name is proposed here for the Indian species.

Stenochilo Hampson.

Stenochilo Hampson, 1895 : 950 ; 1896 : 24.
Genotype : *Stenochilo canicostalis* Hampson.

Referable to the subfamily CRAMBINAE. Frons produced forward, conical, with a corneous point at apex, underside smoothly rounded. Ocelli present, moderately developed.

Antennae in male slightly thicker than in female, very minutely serrate and ciliate, in female setaceous. Proboscis absent. Maxillary palpi triangularly dilated with scales. Labial palpi porrect, short, one and a half times the length of frons, smoothly scaled. Fore wing long and very narrow; apex rectangular, inner margin lobed towards base. Vein 3 arising a little before lower angle of the cell, 4 and 5 separate at origin, 6 and 7 shortly stalked, 8 and 9 stalked, 10 from the cell and a little away from 8 and 9, 11 free. Hind wing with vein 3 arising from near lower angle of cell, 4 and 5 from a point, 6 from upper angle, 7 and 8 stalked, close to 6.

Male genitalia (Pl. VIII).—Vinculum (fig. 2, *v.*) moderately enlarged, transverse, not produced distally into a process. Harpe divided, costa produced as a filiform process with a broad, lobed base. Uncus (fig. 4) in the form of a large, sharply pointed hook. Gnathos spatulate; anellus a small, moderately bent plate.

Female genitalia (Pl. X, fig. 9).—Lobes of ovipositor (*o*) reduced; supporting rods of ovipositor and 8th segment collar very long; 8th to 10th segments greatly enlarged and telescopic.

Range: India; Ceylon.

Remarks: In 1895, when Hampson proposed this genus, he based his description on a single female example of the type species cited above; in 1896 he recorded a male example, and remarked that the genus is characterized also by the absence, in the male, of vein 5 of the hind wing. As an examination of two more male examples of the species by the present writer has revealed the presence of vein 5 in the hind wing, this character has not been mentioned in the definition of the genus given above. It may also be pointed out here that the stalk of veins 6 and 7 in the fore wing is much shorter in the male specimens examined than in the females. The structure of uncus and gnathos in the male genitalia and of the ovipositor and terminal abdominal segments of the female is very characteristic, and at once distinguishes this genus from the others considered in this paper.

Stenochilo canicostalis Hampson (Pl. VIII, figs. 2, 4, 6; Pl. X, fig. 9).

Stenochilo canicostalis Hampson, 1895 : 950; 1896 : 25.
Chilo submedianalis Hampson, 1919*c* : 58. (Syn. n.)

♂. Head and thorax straw-coloured, suffused with red-brown except antennae, which have dark brown and whitish rings. Fore wing similar to thorax, but also with whitish and dark brown to fuscous scales. The whitish scales sparse and very irregularly dispersed, forming a rather whitish fascia running along the costal margin, two small to medium-sized patches lying immediately outside the cell and a patch a little below the middle of the cell, and also thinly sprinkled in the submedian area and on the disk below vein 2; the dark brown scales forming a short fascia, in and beyond the cell (interrupted by the white patches mentioned above), and rather indistinct dark lines between the veins in the submedian area and a few patches lying by the side of the whitish spot and scales below the cell. Terminal series of spots indistinct, fuscous. Fringe reddish-brown, slightly darker near base. Hind wing tinged with brown except near base, which is hyaline white; fringe whitish distally.

♀. Larger; fore wing variable in coloration, on the whole with more and widely scattered whitish scales than the male. The fascia outside the cell usually broken into three dark reddish-brown to fuscous spots by two whitish patches. Sometimes a dark basal fascia, irrorated with white scales, present. Hind wing hyaline white except on the margin, which is tinged with brown; fringe pure white.

Male genitalia.—Vinculum (Pl. VIII, fig. 2) greatly enlarged, like a transverse collar (V.) curved beneath, not produced distally into a process, but truncate in the middle. Harpe divided ; costa produced into a more strongly chitinized and moderately long filiform process with a broad, lobed base which is quadrate in outline, smoothly margined proximally and finely toothed distally ; the apical part of harpe produced into a narrow spatula, which is covered all over with hair, which is short and sparse on the inner side, and long and dense on the outer. Tegumen (fig. 4) triangular, a little longer than the base, strongly sclerotized apically and laterally ; uncus more heavily chitinized, like a large, sharply-pointed hook ; gnathos moderately long, narrowed near the base, straight and spatulate distally. Anellus (fig. 2) comprising a small, moderately bent subcircular plate. Aedeagus (fig. 6) tubular, narrow, nearly as long as harpe, distal half weakly chitinized on the dorsal surface ; no cornutus.

Female genitalia.—The ovipositor and apical abdominal segments elongate and telescopic as described for the genus. An elongate, heavily sclerotized genital plate, which is triangularly emarginate distally, arising from the lower wall of the genital opening ; ductus bursae narrow, moderately long and chitinized towards the base ; bursa copulatrix oval, without a signum.

Expanse : ♂, 20–24 mm. ; ♀, 26–30 mm.

Types : Stenochilo canicostalis Hampson (a female from Hillaya, Sind) and *Chilo submedianalis* Hampson (a male from Batticaloa, Ceylon) in the British Museum.

Material examined : 3 males and 4 females from the following localities :

INDIA : Hillaya, Sind, —.iv.1886 (*Moore* Coll.) ; Calcutta, 1858 (*Atkinson*).

CEYLON : Batticaloa, —.v.1906 (*Green*) ; Puttalam (*Mackwood*).

Biology : Unknown.

Remarks : The specimens from India and Ceylon, hitherto placed under *canicostalis* and *submedianalis* respectively, agree in the external characters as well as those of the male and female genitalia. The two names are therefore treated here as synonyms.

Bissetia gen. n.

Genotype : *Chilo steniellus* Hampson.

Referable to the subfamily CRAMBINAE. Frons (Pl. I, fig. 9) produced forward, conical, with a rather large, corneous, pointed apex ; the underside of frons flattened near the base and produced into a conical ridge. Ocelli absent. Antenna in the male (Pl. VIII, fig. 10) distinctly serrate, each segment subquadrate in outline and well separated from the other ; in the female minutely serrate, much narrower and almost setaceous. Proboscis poorly developed ; maxillary palpi triangularly dilated with scales ; labial palpi very long, over three times the length of frons, porrect, slightly curved downwards and narrowed distally, covered with long and compact scales (Pl. I, fig. 9). Fore wing long and narrow, apex rectangular in male, slightly more pointed in female. Vein 3 arising distinctly away from lower angle of the cell, 4 and 5 separate from the cell, though close to each other ; 6 from just below the apex, 7 from the apex ; 8 and 9 stalked, arising a little away from base of 7 and both reaching the costal margin ; 10 from the cell and a little distance away from 8 and 9 ; 11 free. Hind wing with vein 3 from a little before lower angle of cell, 4 and 5 shortly stalked or arising from a point ; 6 from upper angle ; 7 and 8 stalked.

Male genitalia.—Vinculum (Pl. VII, fig. 9) moderately enlarged, collar-shaped, not produced distally into a process. Harpe divided. Costa with a pair of broad teeth proximally, the median part minutely dentate, the distal part produced into an elongate, narrow, moderately curved and hairy blade. Uncus and gnathos almost similar (fig. 10), very long and narrow, and slightly curved. Anellus (fig. 8) small, subcircular. Aedeagus (fig. 7) tubular, without a cornutus.

Female genitalia.—Ovipositor moderately long, with normally developed lobes, posterior supporting rods markedly dilate, anterior ones short and narrow ; collar of eighth segment produced ventrally, and fused with the base of a funnel-like structure projecting from the base of the genital opening. Ductus bursae long. Bursa copulatrix oval, with a signum.

Range: North India; Tongking.

Remarks: The only known species of this genus has hitherto been placed under *Chilo*, chiefly on account of the characters of the frons and venation of the fore wing. Bisset (1939), who described it as *Chilo trypetes*, however, pointed out that as its genitalia differed considerably from those of certain other species of *Chilo* examined, he was uncertain of its true position. Subsequent examination by the present writer has revealed that, besides the genitalic differences, there are important external characters by which *Chilo* may at once be separated from *Bissetia*. The shape of the frons in the two genera, though similar, is not identical, there being a prominent corneous point and lower ridge in *Bissetia*; the ocelli are absent in the latter, but well developed in *Chilo*; the antennae in the male are more distinctly serrate (Pl. VIII, fig. 10) than those of *Chilo* (fig. 8). The only other genus (among the genera considered in this paper) with which *Bissetia* could be confused on account of the conical structure of the frons and the free vein 11 of the fore wing is *Stenochilo*, which may, however, be easily distinguished from the others by its shortly stalked veins 6 and 7 of the fore wing. On the basis of genitalic characters also the two are easily distinguishable. (See remarks on *Stenochilo*.)

Bissetia steniellus (Hampson) (Pl. VII, figs. 7–10; Pl. X, fig. 11).

Chilo steniellus Hampson, 1899 : 305.
Chilo griseoradians De Joannis, 1930 : 603. (Syn. n.)
Chilo trypetes Bisset, 1939 : 47, 48. (Syn. n.)

♂. Head and thorax whitish to pale grey-brown. Palpi with mixed scales varying from reddish-brown to pale fuscous. Fore wing pale grey-brown irrorated with fuscous and suffused with fuscous in the interspaces, leaving the veins slightly paler. The series of terminal spots dark and small; fringe slightly shiny, uniformly fuscous to rather pale fuscous. Hind wing white.

♀. Larger; fore wing with fewer fuscous scales, resulting in much lighter general coloration. Hind wing white.

Male genitalia.—Vinculum (Pl. VII, fig. 9) moderately enlarged, collar-shaped, curved in the middle and bent at the sides, slightly truncate at the median part of the apical margin. Harpe greatly enlarged, divided, the costa produced into a pair of broad teeth proximally, the median part minutely dentate, more heavily chitinized and sparsely hairy, the distal part produced into an elongate, narrow and moderately curved blade covered with long, rather dense hairs. Tegumen (fig. 10) triangular; sides longer than the base, rather heavily chitinized at the apex and sides. Uncus rather straight, narrow and nearly equal to length of tegumen, pointed at apex and with a few short hairs. Gnathos similar to uncus, but slightly flattened distally on the side facing uncus, rather truncate at apex and without setae. Anellus (fig. 8) a small, moderately bent, subcircular plate with a slight emargination distally. Aedeagus (fig. 7) tubular, about five times as long as wide, slightly membranous distally.

Female genitalia.—Ovipositor (Pl. X, fig. 11) as described for the genus; the process projecting from ventral wall of genital opening funnel-shaped, with oblique opening and three folds (one median and two lateral) in the wall; ductus bursae sclerotized and with honeycombed appearance at one-third of its length. Bursa copulatrix pear-shaped, with a fairly large, spotted signum in the middle of the ventral surface.

Expanse: ♂, 25–27 mm.; ♀, 29–32 mm.

Type : *Chilo steniellus* Hampson, a male (from Tezpore, Assam), and *Chilo trypetes* Bisset, a male (also allotype and paratypes from Gurdaspur, Punjab), in the British Museum. *Chilo griseoradians* de Joannis, a paratype (female, from Tongking), also in the British Museum.

Material examined : 6 males and 11 females from the following localities:

INDIA : Assam : Tezpore. Punjab : Gurdaspur, larva boring in sugar-cane, 22, 26. viii. 1933 ; 18, 19. viii. 1936 (*D. Nath*).

INDO-CHINA : Tongking.

Biology : Reported to feed exclusively on sugar-cane, and showing preference for the "*barani*" (rain-grown) crop in the Punjab. Rahman and Tandon (1940) have also recorded striking differences in habits between this species (see *Chilo trypetes*) and other sugar-cane moth-borers, not excluding species of other genera of CRAMBINAE. There are only two generations a year, the second being passed mostly in hibernation from November to June. The damage is most severe when the plants are large, and is estimated at 15 to 20 per cent. In their earlier stages the larvae are gregarious. The injury caused by this species is characterized by the drying up of the entire whorl of top leaves, instead of the condition known as "dead heart," in which only the central shoot dries up. The morphology of the larva (see *C. trypetes*) and pupa has been published by Isaac and Rao (1941) and Isaac and Venkatraman (1941), who also point out important differences in structure between this and other species of *Chilo*, *Diatraea* (in the old sense), etc., boring into sugar-cane in India.

Remarks : The synonymies proposed above are based on examination of the two types and the paratype mentioned above. The genitalic as well as the external characters are very characteristic of the species, though slight variations in the tone of the fore wings may occur.

Coniesta Hampson.

Coniesta Hampson, 1919 : 540.
Genotype : *Chilo araealis* Hampson, 1912 : 1250.

Referable to the subfamily CRAMBINAE. Frons produced forward, conical, with a corneous point, and sometimes flattened (near base) on the underside. Ocelli present, usually very small and poorly developed. Antennae in the male minutely serrate, usually ciliate, sometimes entirely clothed with scales ; in the female usually setaceous, ciliate or otherwise, as in the male. Proboscis poorly developed ; labial palpi over three times the length of the frons, porrect, slightly down-curved apically and clothed with long hairs and scales. Fore wing with apex slightly to distinctly produced ; vein 3 arising from well before lower angle of cell ; 4 and 5 from the cell, close together, 5 from just above the angle ; 6 from below upper angle, distinctly away from 7, which arises from the apex ; 8 and 9 stalked, usually arising from close to 7 ; 10 usually from the cell ; sometimes 8, 9 and 10 stalked, arising away from 7 ; 11 anastomosing with 12. Hind wing with vein 3 from before lower angle of cell ; 4 and 5 stalked, or from a point on the lower angle ; 6 from upper angle, sometimes free, usually stalked with 7 + 8.

Male genitalia.—Vinculum moderately to greatly developed, usually produced into a moderately long process apically. Harpe divided. Costa produced into various shapes, the median apical part formed into an elongate and hairy structure, and the proximal usually enlarged. Tegumen triangular, sclerotized at apex and on sides. Uncus and gnathos dissimilar (except in *albipennella* Hampson) ; uncus usually stubby. Anellus small, disk-shaped ; aedeagus tubular.

Female genitalia.—Lobes of ovipositor normally developed, with usually broad supporting rods. Eighth segment with short and narrow supporting rods, the ventral anterior margin of the segment produced to reach and sometimes to fuse with a rather heavily sclerotized tongue-, funnel- or ring-like structure at the genital opening. Ductus bursae long and narrow. Bursa copulatrix ovate, usually with a signum.

Range: India; Central Africa.

Remarks: This genus has hitherto contained three species, one (the type of the genus) from India, and two from Central Africa. Examination of the male genitalia of the Indian and one of the African species (*C. undilinealis* Hampson) leaves no doubt that the two are congeneric. Certain Indian species hitherto placed in *Diatraea*, *Argyria* (*Platytes*) and *Chilo* appear to be closely related to the genotype of *Coniesta* in their genitalic and external characters, except that vein 10 of the fore wing arises from the cell instead of being stalked with 8 + 9, as is the case in the three species which originally constituted the genus. The present writer has not been able to find any other constant character that would support this division based on the stalking or otherwise of vein 10 with 8+9. Consequently he has not placed much emphasis on this character which is only one of the several mentioned by Hampson—in the definition of the genus given above. Nothing is known of the biology of the species here placed in it, and seven of the ten species are each known only by a few examples of the same sex. A different classification may be desirable when more is known about them. At present only the various more closely related species are indicated by species-groups in the following key.

Key to the Species of *Coniesta* Hampson.

Based on external characters.

1. Fore wing with vein 10 stalked with 8+9 (*araealis* Group) . . . . 2.
Fore wing with vein 10 from cell, not stalked with 8+9 . . . . . 3.
2. Larger (expanse, ♂, 26 mm.); fore wing with termen having a pair of dark spots above tornus; fringe with a dark line near base; hind wing with veins 4 and 5 from lower angle. (S. India) *araealis* (Hampson)
Smaller (expanse, ♂, 18–20 mm.); fore wing with termen having 4 or 5 dark spots; fringe uniformly coloured, ochreous; hind wing with veins 4 and 5 stalked. (S. India) . . . . *hampsoni* sp. n.
3. Fore wing with vein 10 approximated to 8+9; with post-median and subterminal lines formed of brown lunules placed mostly on the veins. (Ceylon) . . . . *lunilinealis* (Hampson).
Fore wing with vein 10 not approximated to 8+9; without series of lunulate spots on veins . . . . 4.
4. Antennae not ciliate, but clothed entirely with small scales; fore wing with the apex acutely produced; hind wing with vein 6 from upper angle, not stalked with 7+8 (*aculeata* Group) . . . . 5.
Antennae ciliate, scales restricted in the usual way to form a dorsal line only; fore wing with the apex only moderately produced; hind wing with vein 6 stalked with 7+8 . . . . 6.
5. Larger (expanse, ♀, 20 mm.); frons with a corneous apical point and with the underside, near base, flattened and formed into a small conical ridge; fore wings lighter, mostly yellowish-white, terminal spots absent. (Sikkim, N. India) . . . . . . *aculeata* (Hampson).

Smaller (expanse, ♀, 17 mm.); frons with a corneous apical point, but without the underside being flattened and formed into a ridge; fore wing more ochreous, terminal spots present though indistinct. (Belgaum, S. India) . . . . *belgaumensis* sp. n.

6. Expanse 16–30 mm. Fore wing irrorated mostly with fuscous, forming an oblique shade of various dimensions from apex to vein 3 and beyond; usually with a dark discal spot and a subterminal line; fringe lighter at base, with three or four fuscous lines distally (*albipennella* Group) . . . . 7.

Expanse 36–40 mm. Fore wing not with the above-mentioned pattern; ochreous, either suffused with brownish rufous or very sparsely irrorated with red-brown or fuscous; fringe with only one dark line . 9.

7. The oblique fuscous shade wide, extending from apex and termen to base of cell and vein 2; without distinct paler streaks in the middle of interspaces; the pale subterminal line defined by ochreous on outer side only. (N. India) . . . . *albipennella* (Hampson).

The oblique fuscous shade narrow, extending from apex and termen to below end of cell as far as vein 2; with paler streaks in the middle of interspaces; the pale subterminal line defined by ochreous on each side . . . . 8.

8. Expanse 20 mm. Frons widely conical, with the corneous point small and directed downward; the oblique fuscous shade not diffused towards tornus. (Ceylon) . . . . *strigulalis* (Hampson).

Expanse 26–30 mm. Frons narrowly conical, with the corneous point at apex directed forward; the oblique fuscous shade diffused towards tornus. (N. India) . . . . *diaperalis* (Hampson).

9. Expanse 40 mm. Fore wing ochreous yellow, very sparsely irrorated with red-brown to fuscous, with terminal black spots; fringe lighter near base. (Ceylon) . . . . *flavalis* (Hampson).

Expanse 36 mm. Fore wing ochreous, uniformly suffused with brownish rufous; the inner area with slightly darker irrorations; fringe dark near base. (Upper Burma) . . . . *rufulalis* (Hampson).

Coniesta araealis (Hampson) (Pl. IX, figs. 1, 4, 7).

Chilo araealis Hampson, 1912 : 1250.
Coniesta araealis (Hampson), Hampson, 1919 : 540.

♂. Head and palpi straw-coloured with the median dorsal part whitish. Fore wing ochreous to light straw-coloured, slightly irrorated with brown; veins defined by faint brown to whitish streaks. Traces of an oblique antemedial brown line from vein 2 near base to vein 1; a triangular blackish discoidal spot with a brownish streak from it to termen. Post-medial line oblique and formed of faint dark streaks from costa to vein 6, then very oblique to middle of inner margin and minutely dentate; two black spots on termen above tornus; fringe with a dark line near base. Hind wing whitish except towards the apex, which is light straw-coloured; fringe white. Frons moderately wide, conical, with a well-defined corneous point at the apex; not at all flattened on the underside. Ocelli very minute. Antennae in the male minutely serrate and ciliate. Labial palpi a little over three times the length of frons. Fore wing with the apex slightly produced; vein 10 stalked with 8+9; hind wing with veins 4 and 5 from lower angle; 6 stalked with 7+8, all arising from upper angle.

Male genitalia.—Vinculum (Pl. IX, fig. 1) like a narrow, incomplete collar, produced ventrally into a moderately long process, which is truncate at apex. Harpe greatly developed, divided; the costa proximally produced into a moderately long and heavily chitinized process, and slightly dentate near base of the latter; the distal, hairy part elongate and moderately curved; the remainder of the harpe like the blade of an axe, weakly emarginate distally and moderately curved at the lower edge. Tegumen (fig.4) broadly chitinized toward the apex, narrowly so on the sides; uncus stubby, slightly bent, with apex rounded except for the sharply pointed lower edge, sparsely covered with moderately long hairs; gnathos triangular at base, narrow distally, slightly curved and pointed at the apex, without hairs. Anellus small, oval. Aedeagus (fig. 7) tubular, with a distinct cornutus.

Female unknown.

Expanse : ♂, 26 mm.

Type : A male (from Palni Hills), in the British Museum.

Material examined : 3 males from the following localities:

SOUTH INDIA: Palni Hills (*Campbell*); Kodaikanal, 6000 ft. (*Campbell*); Nilgiri Hills, Pykara, 6500 ft., —.v.1911 (*H. L. Andrewes*).

Remarks : Closely allied to the following species, *C. hampsoni*, from which it may be distinguished by its larger size, coloration, especially that of the termen and fringe of the fore wing, and by the structure of the male genitalia.

Biology : Unknown.

Coniesta hampsoni sp. n. (Pl. IX, figs. 2, 8, 12).

♂. Similar to *C. araealis* in general shape and coloration, but smaller. Fore wing differs from that of *araealis* in being more ochreous, with relatively fewer brown scales, in having well-defined and whiter streaks lining the veins and four or five (instead of only a pair as in *araealis*) terminal dark spots, and in the uniformly coloured fringe. Venation also similar except for veins 4 and 5 of the hind wing being shortly stalked.

Male genitalia.—Differing from those of *araealis* in the following respects—Harpe: the proximal costal process long and slender, rather tapering (Pl. IX, fig. 2), the dentations near its base almost absent; the distal, hairy part more slender; the remainder of harpe, which is expanded like the blade of an axe, deeply emarginate distally and almost straight at the lower edge. Uncus and gnathos (fig. 8) relatively narrower, the latter almost straight distally except for a slight curve at the apex. Aedeagus (fig. 12) tubular, but with a weak wavy bend.

♀. Unknown.

Expanse : ♂, 18–20 mm.

Type : A male in the British Museum; from INDIA, Nilgiri Hills (*Hampson*).

Paratypes : 3 males, also in the British Museum; from Nilgiri Hills, Pykara, 7000 ft., —.iv.1913 (*H. L. Andrewes*).

Biology : Unknown.

Remarks : See under *C. araealis*.

Coniesta lunilinealis (Hampson) (Pl. IX, figs. 5, 6, 10).

Diatraea lunilinealis Hampson, 1919: 545.

♂. Head and thorax ochraceous with dorsal, median parts of palpi and frons lighter. Fore wing ochreous-white suffused with fulvous and irrorated with brown. Veins well defined by lighter streaks; brown irrorations common in the interspaces between the cell and costal margin and between veins 5 and 6; a small, discoidal dark spot on the base of vein 6. A post-medial line, formed of rather lunulate, brown spots, excurved from costa to beyond lower angle of cell, then incurved to middle of inner margin; subterminal line formed by brown lunules, indistinct, excurved to discal fold, situated mostly on the veins.

A few ill-defined, brown spots present near the base and below the cell; terminal series of dark spots absent; fringe uniformly brown or reddish brown. Hind wing white with ochreous tinge towards the apex, fringe similar in colour.

Frons moderately wide, conical, with a small corneous point at apex, not flattened on the underside. Ocelli very small; labial palpi three to four times the length of frons; antennae in the male minutely serrate and ciliate. Fore wing slightly produced; vein 10 arising from the cell and running very close to the stalk of 8+9; hind wing with veins 4 and 5 from lower angle of cell, 6 stalked with 7+8.

Male genitalia.—Vinculum (Pl. IX, fig. 5) greatly enlarged, triangular at base, produced distally into a long process which is a little enlarged towards the apex, the latter rounded or truncate. Harpe divided, with an elongate and more heavily chitinized process arising from the middle of the costa. The distal hairy part narrow and slightly curved; the lower part deeply emarginate on either side before the apex. Tegumen, uncus and gnathos as in *C. hampsoni*. Anellus small, quadrangular. Aedeagus tubular, very long, slightly narrowed distally and with a distinct cornutus.

Female and biology unknown.

Expanse: ♂, 22 mm.

Type: A male (from CEYLON) in the British Museum.

Material examined: 3 males from the following localities:

CEYLON: Nawalapitiya (*Pole*); Kandal, —.iv.1911 (*Mackwood*).

Remarks: In its general appearance, scheme of coloration and the general structure of the genitalia, this species closely resembles the preceding two species, namely, *C. araealis* and *C. hampsoni*, but it differs from them in that vein 10 of the fore wing is free from 8+9, although running very close to their stalk.

Coniesta aculeata (Hampson) (Pl. X, fig. 8).

Diatraea aculeata Hampson, 1903 : 659 (Pl. C, fig. 15).

♀. Yellowish white, head and thorax tinged with pale brown. Fore wing yellowish-white, with interspaces of costal and terminal areas streaked with ochreous. A black discoidal spot. Traces of a very obliquely curved post-medial line from costa to lower angle of cell and of a subterminal line; a brown terminal line, but no terminal series of spots; fringe with two thin, brown lines. Hind wing pure white.

Frons conical with a distinct corneous apical point. Underside flattened near the base, and formed into a small conical ridge with a corneous apex which lies directly below the other point. Ocelli minute. Labial palpi three times as long as frons. Antennae setaceous, not ciliate, but clothed entirely with small scales. Fore wing with the apex produced and acute; vein 10 from cell, not stalked with 8+9; hind wing with veins 4 and 5 stalked; 6 from upper angle, not stalked with 7+8.

♂. Unknown.

Female genitalia.—Lobes of ovipositor (Pl. X, fig. 8) curved apically before the dorsal extremity, and with supporting rods very broadly dilated. Ventral part of the anterior margin of 8th segment produced to join the tongue-like chitinized structure covering the genital opening. Ductus bursae very long and narrow, chitinized near the base. Bursa copulatrix oblong, with a long, slit-like signum (*s.*).

Expanse: ♀, 20 mm.

Type: A female, in the British Museum.

Remarks: No other example has been seen by the present writer. The type is from Sikkim, 2000 ft., —.vi.1896 (*Pilcher*), and is closely related to the following species from Belgaum, Bombay Province, India. The difference in the structure of the frons in the two species is very characteristic.

Coniesta belgaumensis sp. n. (Pl. IX, figs. 3, 9, 11).

♂. Head, thorax and fore wing pale straw-coloured; the latter suffused with ochreous and irrorated with brown, especially in the interspaces of costal and terminal areas. A dark brown discoidal spot at the base of vein 6; the rest of wing sparsely speckled with brown; termen also brown with rather indistinctly marked series of spots; fringe with two fine, brown lines through the middle. Hind wing white, with traces of light straw towards the apex.

Frons conical, with a corneous point at apex, not flattened on the underside. Ocelli minute. Labial palpi four times as long as the frons. Antennae minutely serrate to rather setaceous, though thick, not ciliate but uniformly covered with small scales. Fore wing with the apex produced and acute; vein 10 from cell and not stalked with 8+9. Hind wing with veins 4 and 5 shortly stalked; vein 6 from the upper angle, not stalked with 7+8.

♀. Generally lighter in coloration; fore wing with fewer brown scales, especially in the area below the cell; hind wing whitish. Antennae setaceous, not ciliate, but clothed with small scales.

Male genitalia.—Vinculum (Pl. IX, fig. 3) collar-shaped at base, gradually produced distally in an elongate process, which is slightly narrowed at apex. Harpe divided, with the costa formed into a more heavily sclerotized sharply conical and moderately curved process; the distal hairy part long and slightly narrowed towards the apex; the rest of harpe subquadrate in outline. Uncus (fig. 9) similar in general appearance to those of the preceding species, but less stout and only slightly curved; gnathos also similar but more drawn out at the apex into a sharp point. Aedeagus (fig. 11) tubular, rather short and stout; without a distinct cornutus.

Female genitalia.—Similar to those of *C. aculeata* (Pl. X, fig. 8), but with the signum conical, with a broad base.

Expanse : ♂, 16 mm.; ♀, 17 mm.

Type : A male from INDIA, Belgaum, —.vi.1896 (*Watson*), in the British Museum.

Paratype : A female with the same data as above, also in the British Museum.

Remarks : Closely related to *C. aculeata* Hampson, from which it may be distinguished by the smaller size, smoothness of the underside of frons, slightly more ochraceous and darker coloration of fore wing and the shape of the signum in the female. The male of *aculeata* is not known, nor is the biology of either *aculeata* or *belgaumensis*.

Coniesta strigulalis (Hampson).

Platytes strigulalis Hampson, 1895 : 946.

♀. Head and thorax whitish to pale ochreous; palpi fuscous at sides. Fore wing pale ochreous, with a whitish triangular area on the costa near the apex. Veins whitish except near termen, margined by ochreous excepting veins 3–7, which are narrowly lined by fuscous so as to form together an oblique shade running from apex and along the end of cell to base of vein 2. A dark fuscous spot between the bases of vein 5 and 6. An indistinct, whitish subterminal line, defined on each side by ochreous yellow, excurved from costa to middle of the inner margin. Terminal margin fuscous, with 2–4 piceous spots; fringe with 3–4 fuscous lines except near the base, which is paler. Hind wing light ochreous; fringe whitish, with a pale fuscous line near base.

Frons rather widely conical, with the corneous point directed slightly downward. Ocelli present. Palpi four (or more) times as long as frons. Antennae setaceous and ciliate.

Fore wing with vein 10 from cell, running close to stalk of 8+9; hind wing with veins 4 and 5 shortly stalked, 6 also stalked with 7+8.

Female genitalia.—Ovipositor with the lobes slightly curved posteriorly at the apex, their supporting rods expanded in the middle. Anterior margin of 8th segment produced to join the obliquely cut, funnel-shaped process projecting from the genital opening as in *C. flavalis* (Pl. X, fig. 6). Ductus bursae long and narrow; bursa copulatrix subrounded, without a signum.

Expanse: ♀, 20 mm.

Type: A female (not male, as given in the original description) from CEYLON; in the British Museum.

Material examined: 3 females from the following localities:

CEYLON: Exact locality not given (*Green*); Nawalapitiya (*Pole*).

INDIA: Belgaum, —.vii.1895 (*Watson*).

Remarks: Although Hampson (1895) regarded specimens from the Punjab and Assam as belonging to this species, the present writer thinks that at least the Punjab specimen is a male of *albipennella* Hampson, a species placed next to *strigulalis* by Hampson. He regarded all his examples of both these species as males, but the present writer has found his types to be females. The biology of this species is unknown, and the male has not been described.

Coniesta albipennella (Hampson) (Pl. VIII, figs. 5, 11, 12).

Platytes albipennella Hampson, 1895: 946.

♂. Head and thorax chalky white, or suffused with pale ochreous; palpi brownish on sides. Fore wing white to ochreous-white, irrorated with brown and fuscous, forming a similar pattern to that in *strigulalis* except that the fuscous shade is relatively wide, extending from the apex to inside the cell and between vein 2 and the termen. Veins distinctly whitish, with the paler streaks in the interspaces practically absent. The subterminal pale line rather distinct, defined externally only by ochreous. Hind wing whitish, slightly suffused with pale fuscous except near the base; fringe with a pale fuscous line nearer the apex.

Frons widely conical, with a small corneous, apical point, underside with a small ridge. Ocelli, palpi, antennae and venation as in *strigulalis*.

♀. Similar in coloration to the male, except that the shade of the fore wing from the apex to vein 3 is rather pale fuscous and is interrupted by paler streaks in the interspaces; antennae setaceous, ciliate. Hampson's description is of a female (not a male as stated by him), which is exceptionally chalky white.

Male genitalia.—Vinculum, harpe and anellus (Pl. VIII, fig. 5) similar to, but not identical with those of *diaperalis*, the harpe with distal part of costa formed into a short and subrounded process (*a.*). Uncus and gnathos (fig. 12) similar to one another, beak-like, both rather elongate, slightly curved distally and pointed at apex. Aedeagus (fig. 11) tubular, slightly bent at one-third its length, rough and expanded distally.

Female genitalia.—Ovipositor similar to that of *C. rufulalis* Hampson (Pl. X, fig. 4) especially in that there is a funnel-shaped structure at the genital opening which is directly connected with the extension from the ventral, anterior margin of the 8th segment. Ductus long and tubular. Bursa subrounded, with a slit-like signum.

Expanse: ♂, 16–20 mm.; ♀, 18–22 mm.

Type: A female (from Muree), in the British Museum.

Material examined: Males and females from the following localities:

INDIA : Punjab : Muree (*Harford*) ; Kangra Valley, 4500 ft., —.vi.1904 (*Dudgeon*) ; Simla, 7000 ft., —.vii.1898 (*Pilcher*). Assam : Khasia Hills.

Biology : Unknown.

Remarks : Some of these examples have been recorded under *strigulalis* (Hampson, 1895), owing apparently to their similarity in coloration to the latter and to the exceptionally chalky-white appearance of the type of *albipennella*. A study of the genitalia, however, leaves no doubt that the two are distinct, though closely allied species, which show great variation in size and coloration.

Coniesta diaperalis (Hampson) (Pl. X, fig. 10).

Diatraea diaperalis Hampson, 1919 : 545.

♂. Head and thorax whitish to pale ochreous; sides of palpi and thorax tinged with fuscous and red-brown respectively. Fore wing with the coloration similar to that of *strigulalis* except that the interspaces between the cell, vein 10 and costa are also irrorated with red-brown to fuscous. The oblique fuscous shade between the apex and vein 2 relatively narrow, not extending to the area near the end of the cell except its lower angle, and becoming paler and diffuse towards the tornus ; the subterminal pale line rather distinct except in the area of the fuscous shade and defined on each side by red-brown. Hind wing as described for the male of *albipennella*.

Frons conical, with a corneous point ; underside near base slightly flattened and with a short conical ridge ; ocelli very minute. Labial palpi three times as long as frons. Antennae minutely serrate and ciliate. Fore wing with vein 11 from the cells, not stalked with 8+9 ; hind wing with vein 4 and 5 stalked and vein 6 stalked with 7+8.

♀. A little larger and generally paler in coloration than the male. Fore wing with the dark discal and terminal spots indistinct. Hind wing whitish, but tinged with pale fuscous as in the male. Antennae setaceous, ciliate.

Male genitalia.—Vinculum greatly enlarged, collar-shaped, not produced into a process distally, the median ventral part rather flat truncate to slightly emarginate distally. Harpe divided. Costa more heavily chitinized and finely but distinctly dentate on the margin ; apical part produced into an elongate, slightly curved process covered densely with long hairs ; the lower margin of the harpe also produced distally into a sub triangular, slightly more heavily sclerotized and hairy process. Tegumen like that of *C. araealis* ; uncus also similar but rounded, pointed at apex. Gnathos slightly curved, uniformly narrow from near the base to the apex, which is blunt. Vinculum slightly bent ; quadrate plate sub-rounded distally. Aedeagus tubular, similar to that of *Stenochilo canicostalis* (Pl. VIII, fig. 6), without cornutus.

Female genitalia.—Ovipositor similar to that described for *C. aculeata*, but the genital opening formed into a heavily chitinized ring (*r.*), through which a funnel-like structure (*f.*) arising from the floor of the ductus projects. Ductus bursae long and narrow. Bursa copulatrix ovate, with vertical, slit-like signum (*s.*).

Expanse : ♂, 26 mm. ; ♀, 28–30 mm.

Type : A female (from Bhutan), in the British Museum.

Material examined : 1 male and 2 females from the following localities :

INDIA : Bhutan, —.viii.1895 (*Dudgeon*) ; Khasia Hills, —.iv.1894.

Biology : Unknown.

Remarks : Closely allied to the preceding two species in scheme of coloration and general structure. The example (a female) from which Hampson described this species has the scales mostly rubbed off, hence the differences in the coloration given above (from better examples) from that given in the original description. The genitalia in the two cases have been compared and found identical.

Coniesta flavalis (Hampson) (Pl. X, fig. 6).

Diatraea flavalis Hampson, 1919 : 544.

♀. Head and thorax ochreous yellow ; sides of palpi slightly irrorated with red-brown. Fore wing ochreous yellow, very sparsely irrorated with red-brown to fuscous. Terminal area faintly tinged with rufous ; terminal series of spots black, those towards apex smaller ; fringe lighter near base, pale fuscous distally. Hind wing ochreous white, tinged with brown ; termen and fringe tinged with brown.

Frons broadly conical, with apical point very small and near the corneous arch-like ridge bordering the underside. Ocelli present. Labial palpi narrow and very long, about four times the length of the head. Antennae setaceous, ciliate. Fore wing with vein 10 from the cell, free ; hind wing with veins 4 and 5 stalked, and also vein 6 stalked with 7+8.

Female genitalia.—Ovipositor (Pl. X, fig. 6) similar to that described for *C. strigulalis* ; except that the funnel is slightly more distinctly formed ; ductus bursae long and narrow ; bursa oval, without a signum.

Expanse : ♀, 40 mm.

Type : A female (from Ceylon), in the British Museum.

Remarks : Biology and male unknown ; although the frons is not quite typical of the genus, it is similar to that of *strigulalis*, which this species also resembles in the structure of the female genitalia ; both are from Ceylon.

Coniesta rufulalis (Hampson) (Pl. X, fig. 4).

Chilo rufulalis Hampson, 1919 : 58.

♀. Head and thorax ochreous, tinged with brownish rufous. Palpi irrorated with fuscous on the sides. Fore wing ochreous, uniformly suffused with brownish rufous, the inner area with slight dark irroration. Fringe brownish with a darker line near the base. Hind wing ochreous white with a slight brownish tinge ; a faint brownish terminal line to vein 2.

Frons acutely conical with a sharp, corneous apical point. Underside flattened near base and produced into a small, conical, corneous ridge. Ocelli very small. Labial palpi three times the length of frons ; antennae setaceous, ciliate. Fore wing with the apex slightly produced. Vein 10 from cell, not stalked with 8+9 ; hind wing with veins 4 and 5 from lower angle ; 6 shortly stalked with 7+8.

Female genitalia.—Lobes of ovipositor slightly curved before the apex (Pl. X, fig. 4), its supporting rods dilated before the middle. Ventral part of anterior margin of 8th segment produced anteriorly and curved posteriorly to form a funnel at the genital opening. Ductus bursae very narrow and long. Bursa copulatrix spherical without a signum.

Expanse : ♀, 36 mm.

Type : A female from Upper Burma, Kinyua, 23.ix.1900 (*Bingham*), in the British Museum.

Biology : Unknown ; male also unknown.

Remarks : As the fore wing has vein 11 anastomosing with 12 and in view of the characters of the genitalia, there is no doubt that this species does not belong to *Chilo*. Within the genus *Coniesta*, its genitalia are similar to those of the rather smaller species, *C. albipennella*.

Girdharia, gen. n.

Genotype : *Girdharia tauromma*, sp. n.

Referable to the subfamily CRAMBINAE and close to *Coniesta* Hampson. Frons produced forward, conical, the apex with a corneous point, the underside flattened near base and usually produced into a conical ridge, with the apex lying directly below that of the frons. Ocelli well developed. Antennae in the male pectinate and ciliate; when they are extended (Pl. VIII, fig. 9) each segment appears triangular in side view; entirely clothed with scales. Proboscis poorly developed. Maxillary palpi triangularly dilated with scales. Labial palpi about four times the length of frons, porrect, slightly narrowed and down-curved distally, covered with long scales. Fore wings (Pl. X, fig. 2) long and rather narrow, with the apex moderately produced; vein 3 well before lower angle of cell; 4 and 5 from cell; upper angle of cell wide, 6 from below upper angle and away from 7; 8 and 9 stalked, arising from just above the angle and terminating in the costal margin; 10 from cell, and well before the base of 8 and 9; 11 oblique, anastomosing with 12. Hind wing with vein 3 before the lower angle of the cell; 4 and 5 from the angle; 6 from upper angle, stalked with 7 and 8.

Male genitalia.—Vinculum moderately enlarged, broadly truncate at apex; harpe divided, costa with a pair of broad lobes proximally and finely dentate margin distally; the apex produced into two hairy processes, the upper one of which is long and the lower short and stumpy. Uncus and gnathos moderately long, dissimilar; the former laterally compressed, blade-like, moderately curved distally and with pointed apex; the latter narrow, tubular, with a slightly flattened dorsal surface and truncate apex.

Female: Unknown.

Range: India; Indo-China.

Remarks: The genitalic characters given above are provisional, as only a single species of the genus is so far known. On the whole, these characters resemble those of the *albipennella* group of the genus *Coniesta*, from which, however, *Girdharia* is easily distinguished by the pectinate antennae and the well-developed ocelli. Unfortunately, as nothing is known of the biology of *Coniesta*, it is impossible to judge the relationship between these two genera adequately.

Girdharia tauromma sp. n. (Pl. X, fig. 2; Pl. VIII, figs. 1, 3, 7, 9).

♂. Head pale ochreous, palpi irrorated with fuscous. Thorax pale ochreous suffused with pale fuscous on the sides. Fore wing rather produced at the apex (Pl. X, fig. 2), with a white costal stripe which is narrowed at either end and is interrupted by a pair of oblique brown lines (one usually faint), situated a little distance before the apex. Behind the white stripe a cupreous brown fascia passing through the cell and expanding to the apex and about one-third of the termen, and behind this again a pure white fascia almost entirely below the cell and similar to the brown one, except that it has three pairs of brown and very fine streaks in the interspaces between the post-median and subterminal areas, a thin brown subterminal wavy line with a similar but paler line bordering it on the inner side, and faint brown coloration at the termen and the series of terminal spots (4) piceous. The posterior area cupreous brown with the terminal spot above the tornus larger than the rest. Sometimes the white stripe and fascia very sparsely irrorated with pale fuscous. Fringe with a moderately wide, white line at the base, followed by four fuscous lines close together distally. Hind wing pure white, the apex with a pale fuscous marginal line. Fringe white, with a similar line through the middle, as far as vein 3. Frons, ocelli, antennae, etc., as described for the genus.

♀. Unknown.

Male genitalia.—Vinculum (Pl. VIII, fig. 1, *v.*) moderately enlarged, V-shaped with a broadly truncate apex. Harpe divided. Costa with a pair of broad teeth (*t.*) proximally and finely dentate margin distally. Apical part (*p.*1) produced into a long, moderately broad and curved process covered with long and dense hairs; the part (*p.*2) immediately below its base produced into a short, stumpy and hairy process, which is subrounded at the apex. Tegumen (fig. 3) subtriangular, sclerotized at the apex and sides. Uncus and gnathos moderately long; the former laterally compressed, moderately curved distally, pointed at apex and with moderately long hairs on its lower margin. Gnathos narrowed from the base into a straight tubular structure, which is rather flattened on the dorsal surface and slightly bent before the apex, which is truncate. Anellus (fig. 1, *an.*) a quadrate moderately bent plate. Aedeagus (fig. 7) tubular, slightly bent before the middle, weakly chitinized near the base and the extreme apex.

Expanse : ♂, 25–28 mm.

Type : A male from INDIA, Kangra Valley (Punjab), 4500 ft., —.vii.1899 (*Dudgeon*), in the British Museum.

Paratypes : Two: a male from INDO-CHINA (—.ix.1912) in Muséum National d'Histoire Naturelle, Paris; a male from INDIA, Madras (December), in the British Museum.

Remarks : This species has hitherto been confused with *Crambus torrentella* Meyrick (1878), and has been called *Chilo torrentellus* (Meyrick) by Hampson (1895, 1896), Ghosh (1921) and Fletcher (1928). Meyrick's *torrentella*, however, is Australian, and it resembles the species now described only superficially in coloration, and even in this latter respect the two species show notable differences in detail (compare figs. 2 and 3, Pl. X). In the Australian species the coloration of the two stripes is silvery white as against pure white in *G. tauromma*, and the median white fascia extends to the apex in the former, while in the latter it remains far below the apex. Fletcher and Ghosh (1920, p. 393) first described the biology of *G. tauromma*, referring to it as "? Pyralid borer." Its larva was known to bore into fully grown plants of *Saccharum spontaneum*. Later, Ghosh (1921) described its biology and its larva and pupa. Only one generation is completed in a year in Pusa. The larva resembles that of *Bissetia steniellus* (Hampson) in general appearance, and the pupa is characterized by the presence of conical, spinous processes on the 4th to 9th abdominal segments and by the hind extremity being protuberant, conical and without any spines. Fletcher and Ghosh (1920, Pl. 64, fig. 1) give a figure of its larva, and Ghosh (1921, Pl. XX, fig. 1) gives figures of its pupa and adult.

OTHER SPECIES RECORDED FROM INDIA.

The following species described in *Chilo* and *Diatraea* from India have not been dealt with in the foregoing pages, for the reasons stated:

(1) *Chilo dichromellus* (Walker): Erroneously recorded by Hampson (1896: 27) from India (Bhutan) and by Hutson (1941) and Vinson (1942) as boring rice in Ceylon. It is, in fact, a New World species, the correct name for which is *Epina dichromella* Walker. (For detailed information see Kapur, 1948: 191).

(2) *Chilo pulverulentus* (Warren): Transferred by Hampson (1895: 957) from "*Ebulea* (?)" to *Chilo*, but actually belongs to the subfamily PYRAUSTINAE and apparently to *Pyrausta* Schrank, of which *Ebulea* is a synonym.

(3) *Chilo fuscidentalis* Hampson (1896: 956): Also belongs to the subfamily PYRAUSTINAE.

(4) *Chilo saccharicola* Fletcher (1928: 59).

(5) *Diatraea kanra* Fletcher (1928: 59).

(6) *Diatraea batri* Fletcher (1928: 59).

(7) *Diatraea ikri* Fletcher (1928: 60).

Descriptions of these four species do not appear to have been published, but notes on their biology and figures of the immature stages as well as of the moths were published by Fletcher and Ghosh (1920). No example of them is known to the present writer.

(8) *Diatraea saccharalis* (Fabricius): Apparently recorded in error by Hampson (1899 : 306) from Ceylon; does not occur in the Oriental region.

(9) *Diatraea ustalis* Hampson (1919 : 543–544): Represented in the British Museum by a unique female example which is the type. It does not belong to *Diatraea*, nor is it allied to any of the Oriental species hitherto placed in that genus. It resembles *Coniesta* in the shape of the frons (which is well produced forward and acutely conical with a corneous point) and in the venation of the fore wing, but it differs from it in the absence of ocelli, slight dilation of the labial palpi, and the structure of the female genitalia, which have a part of the ovipositor peculiarly modified into a sword-like process, which does not occur in any other species dealt with in this paper. Knowledge of the structure of the male of this species is necessary before its true affinities can be decided.

SUMMARY.

The Indian species of Crambine moths dealt with in this paper belong to the following eight genera, of which the last four are new and are described: *Chilo*, *Coniesta*, *Proceras*, *Stenochilo*, *Bissetia*, *Chilotraea*, *Drasa* and *Girdharia*. Six new species are described: *Chilo tamsi*, *Chilotraea bandra*, *Coniesta hampsoni*, *Coniesta belgaumensis*, *Girdharia tauromma* and *Proceras indicus*.

New synonymies proposed are as follows (the names sunk being given in square brackets):

Bissetia steniellus (Hampson)[=*Chilo griseoradians* de Joannis and *Chilo trypetes* Bisset].
Chilo luteellus (Mots.) [=*Chilo gensanellus* Leech].
Chilotraea infuscatellus (Snellen) [=*Argyria sticticraspis* Hampson, *Diatraea calmina* Hampson and *Diatraea shariinensis* Eguchi].
Stenochilo canicostalis Hampson [=*Chilo submedianalis* Hampson].

Species transferred to already known or new genera are as follows (the name of the old genus being given in brackets): *Bissetia* [*Chilo*] *steniellus* (Hampson); *Chilo* [*Argyria*] *tumidicostalis* (Hampson); *Chilotraea* [*Chilo*] *auricilia* (Dudgeon); *Chilotraea* [*Chilo*] *ceylonicus* (Hampson); *Chilotraea* [*Chilo*] *infuscatellus* (Snellen); *Coniesta* [*Chilo*] *rufulalis* (Hampson); *Coniesta* [*Diatraea*] *aculeata* (Hampson); *Coniesta* [*Diatraea*] *diaperalis* (Hampson); *Coniesta* [*Diatraea*] *flavalis* (Hampson); *Coniesta* [*Diatraea*] *lunilinealis* (Hampson); *Coniesta* [*Platytes*] *albipennella* (Hampson); *Coniesta* [*Platytes*] *strigulalis* (Hampson); *Drasa* [*Diatraea*] *cashmirensis* (Hampson); and *Proceras* [*Chilo*] *venosatus* (Walker).

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EXPLANATION OF PLATES.

PLATE I.

Heads of: (1) *Chilotraea auricilia* (Dudgeon); (2) *Chilotraea infuscatellus* (Snellen); (3) *Argyria argentana* (Martyn); (4) *Diatraea saccharalis* (F.); (5) *Chilo tumidicostalis* (Hampson); (6) *Proceras sacchariphagus* Bojer; (7) *Chilo phragmitellus* (Hübner); (8) *Chilo zonellus* (Swinhoe); (9) *Bissetia steniellus* (Hampson).

PLATE II.

Parts of male genitalia of: (1, 6, 7) *Chilo phragmitellus* (Hübner); (2) *Chilo suppressalis* (Walker); (3) *Chilo zonellus* (Swinhoe); (4) *Chilo luteellus* (Motschulsky); (5) *Chilo tumidicostalis* (Hampson).

PLATE III.

Aedeagus of: (1) *Chilo suppressalis* (Walker); (2) *Chilo zonellus* (Swinhoe); (3) *Chilo tumidicostalis* (Hampson); (4) *Chilo phragmitellus* (Hübner); (5) *Chilo luteellus* (Motschulsky). (6) Tegumen of *C. suppressalis*; (9) the same of *C. tumidicostalis*. (7) Anellus of *C. suppressalis*; (8) the same of *C. zonellus*. Female genitalia of: (10) *C. phragmitellus*; (11) *C. tumidicostalis*; (12, 13) *C. suppressalis*; (14) *Chilo tamsi* sp. n.; (15) *C. zonellus*.

PLATE IV.

1–5. *Chilotraea infusatellus* (Snellen): (1) Harpes and vinculum; (2) aedeagus; (3) anellus; (4) tegumen; (5) female genitalia. 6–11. *Chilotraea ceylonicus* (Hampson): (6) Head; (7) harpes and vinculum; (8) aedeagus; (9) anellus; (10) female genitalia; (11) tegumen.

PLATE V.

1–5. *Chilotraea auricilia* (Dudgeon): (1) Harpes, vinculum, etc.; (2) anellus; (3) tegumen; (4) aedeagus; (5) female genitalia. 6–10. *Chilotraea bandra* sp. n.: (6) harpes and vinculum; (7) anellus; (8) tegumen; (9) aedeagus; (10) female genitalia.

PLATE VI.

Harpes and vinculum of: (1 and 6) *Proceras venosatus* (Walker); (3) *Proceras indicus* sp.n.; (4) *Proceras sacchariphagus* Bojer. (2) Anellus of *P. sacchariphagus*. (5) Tegumen of *P. venosatus*. Aedeagus of: (7) *P. indicus*; (8 and 10) *P. venosatus*; (9) *P. sacchariphagus*. Female genitalia of: (11) *P. sacchariphagus*; (12) *P. venosatus*; (13) *P. indicus*.

PLATE VII.

1–3. *Diatraea saccharalis* (F.): (1) Harpes, vinculum and anellus; (2) tegumen; (3) aedeagus. 4–6. *Drasa cashmirensis* (Hampson): (4) Harpes and vinculum; (5) aedeagus; (6) tegumen. 7–10. *Bissetia steniellus* (Hampson): (7) aedeagus; (8) anellus; (9) harpes and vinculum; (10) tegumen. 11, 12. *Argyria argentana* (Martyn) (11) tegumen; (12) harpe and vinculum.

PLATE VIII.

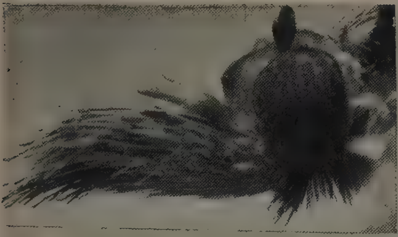
(1) Harpe, anellus (*an.*) and vinculum (*v.*) of *Girdharia tauromma* sp. n. (p_1, p_2, hairy processes of harpe; *t.*, one of the pair of costal teeth); (2) the same of *Stenochilo canicostalis* Hampson; (5) the same of *Coniesta albipennella* (Hampson) (*a* = costa). Tegumen of: (3) *G. tauromma*; (4) *S. canicostalis*; (12) *C. albipennella*. Aedeagus of: (6) *S. canicostalis*; (7) *G. tauromma*; (11) *C. albipennella*. Antenna of: (8) *Chilo phragmitellus* (Hübner); (9) *G. tauromma*; (10) *Bissetia steniellus* (Hampson).

PLATE IX.

Harpes, anellus and vinculum of: (1) *Coniesta araealis* (Hampson); (2) *Coniesta hampsoni* sp. n.; (3) *Coniesta belgaumensis* sp. n.; (5) *C. lunilinealis* (Hampson). Tegumen of: (4) *C. araealis*; (8) *C. hampsoni*; (9) *C. belgaumensis*; (10) *C. lunilinealis*. Aedeagus of: (6) *C. lunilinealis*; (7) *C. araealis*; (11) *C. belgaumensis*; (12) *C. hampsoni*.

PLATE X.

Moths of: (1) *Argyria argentana* (Martyn); (2) *Girdharia tauromma* sp. n.; (3) *Chilo torrentella* (Meyrick). Female genitalia of: (4) *Coniesta rufulalis* (Hampson); (5) *Diatraea saccharalis* (F.); (6) *Coniesta flavalis* (Hampson); (7) *Argyria argentana*; (8) *Coniesta aculeata* (Hampson); (9) *Stenochilo canicostalis* Hampson; (10) *Coniesta diaperalis* (Hampson); (11) *Bissetia steniellus* (Hampson).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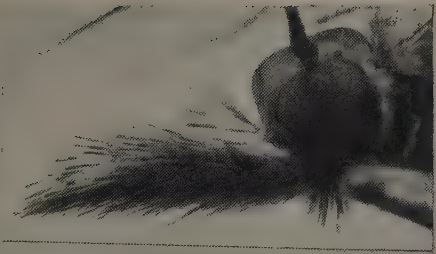
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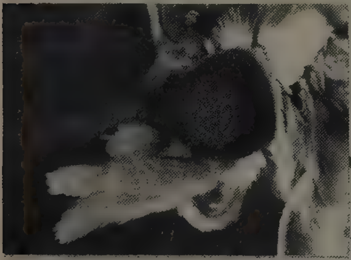
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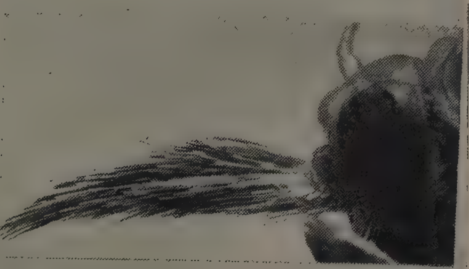
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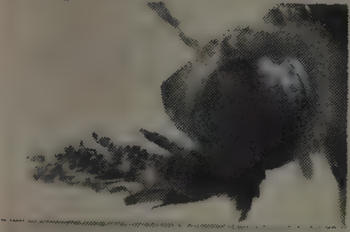
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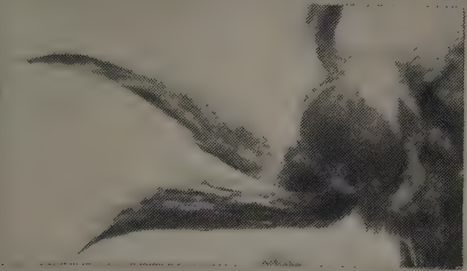
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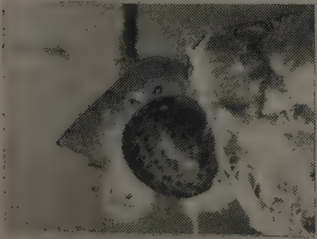
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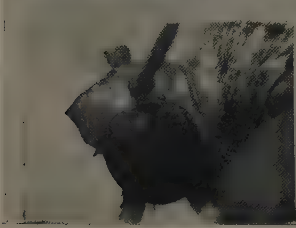
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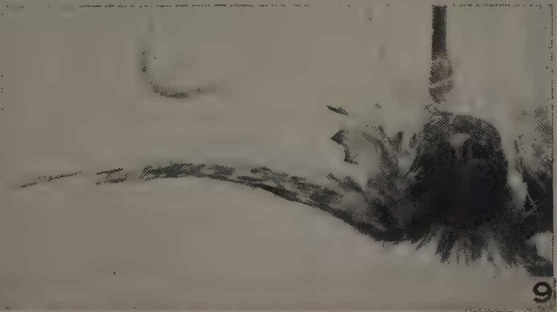
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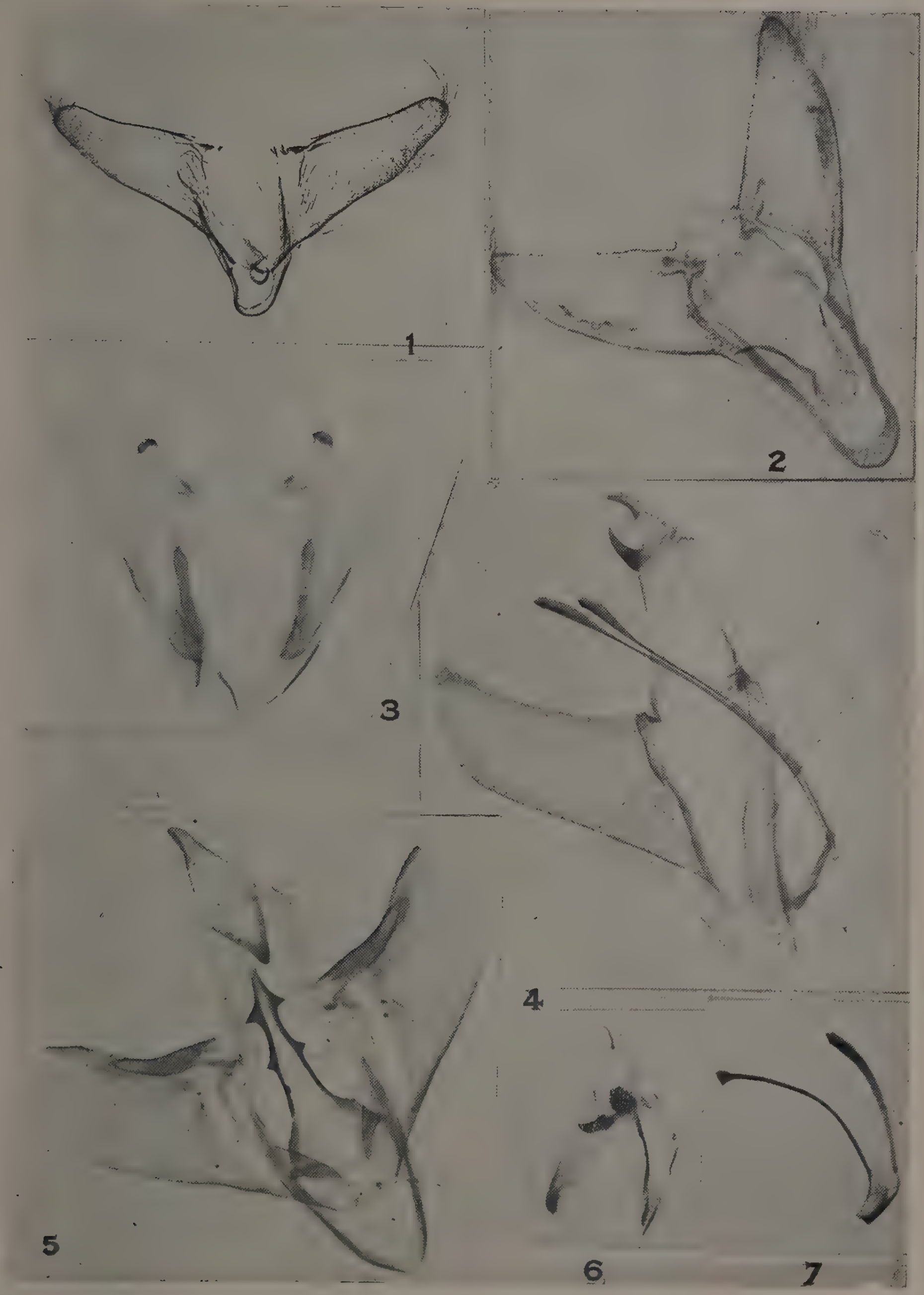

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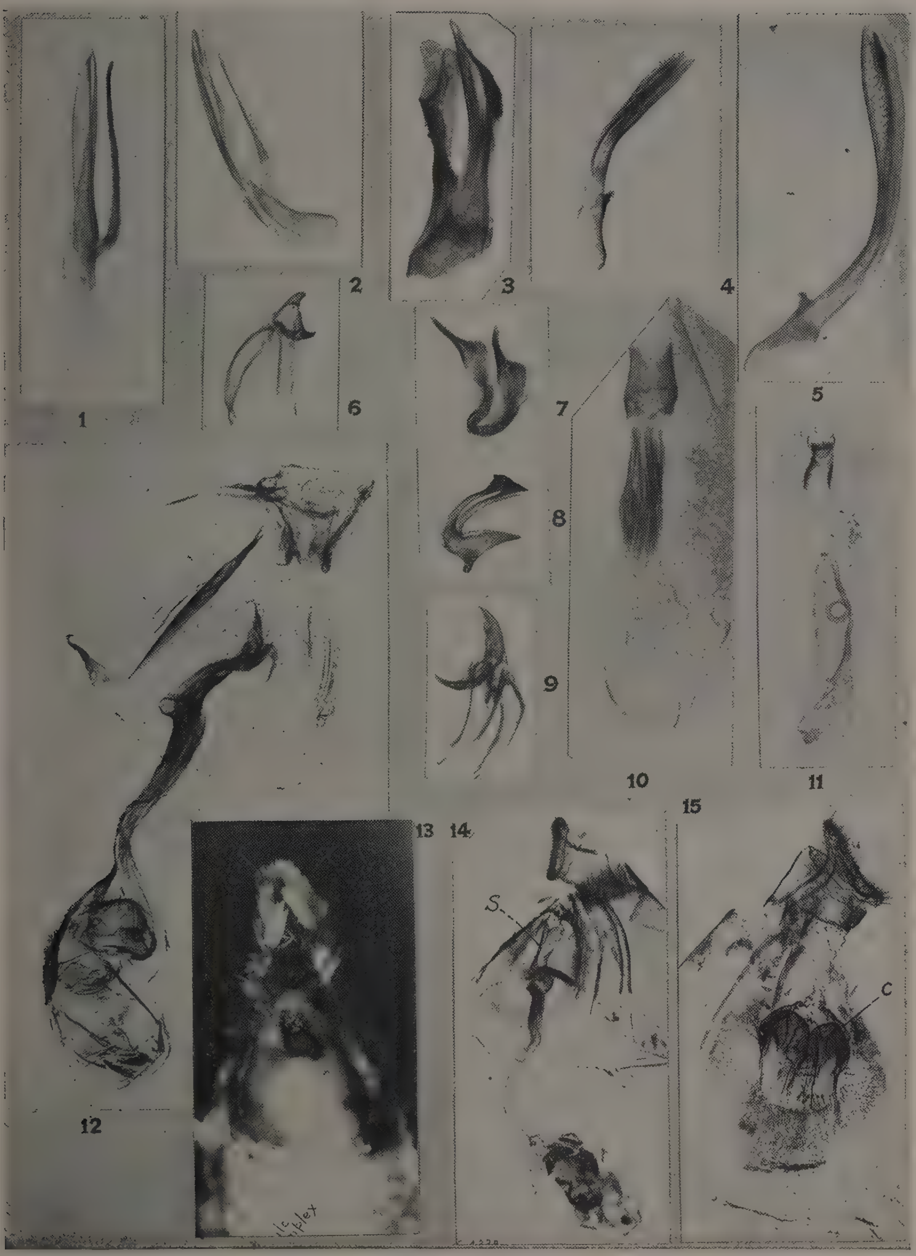
PLATE III.



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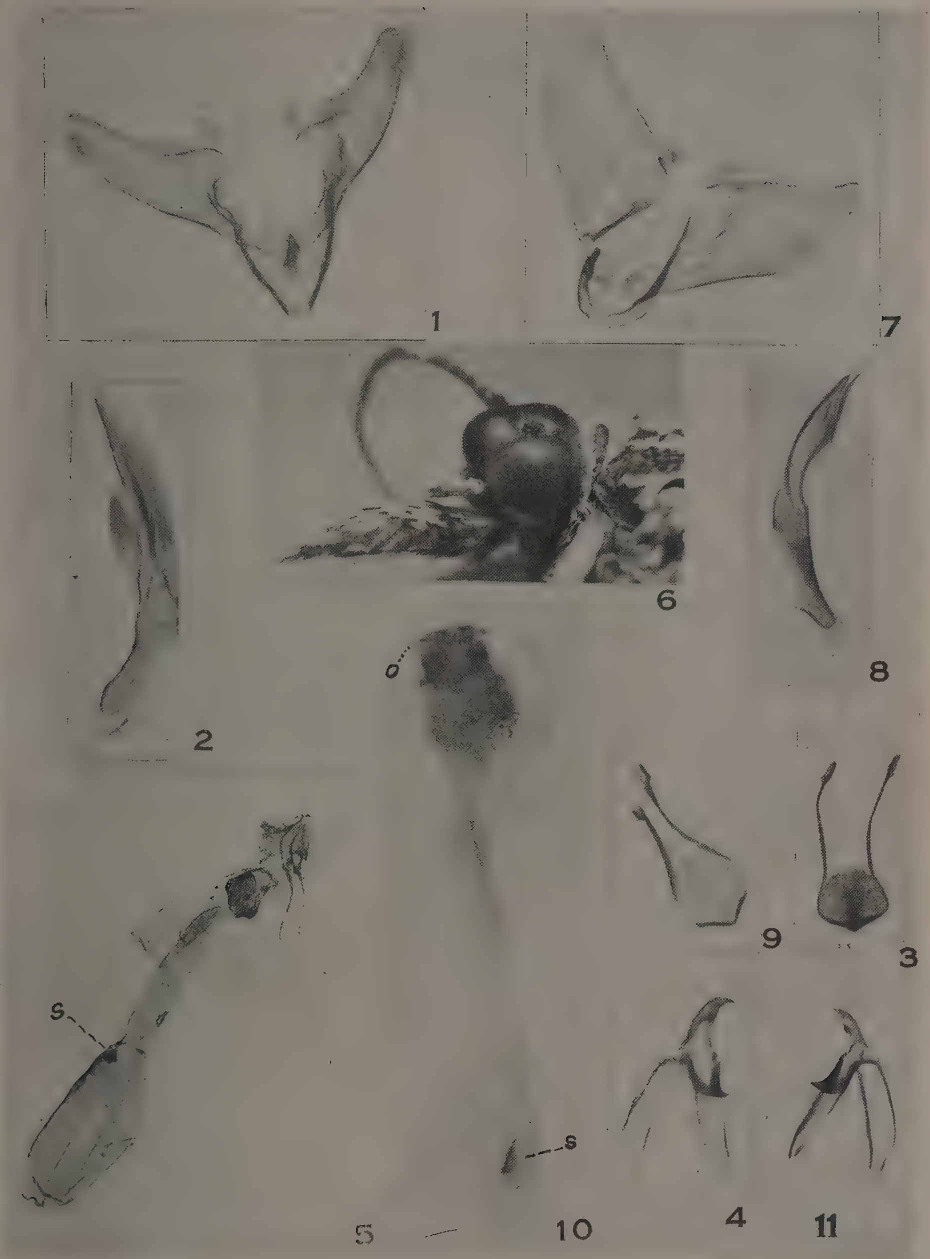

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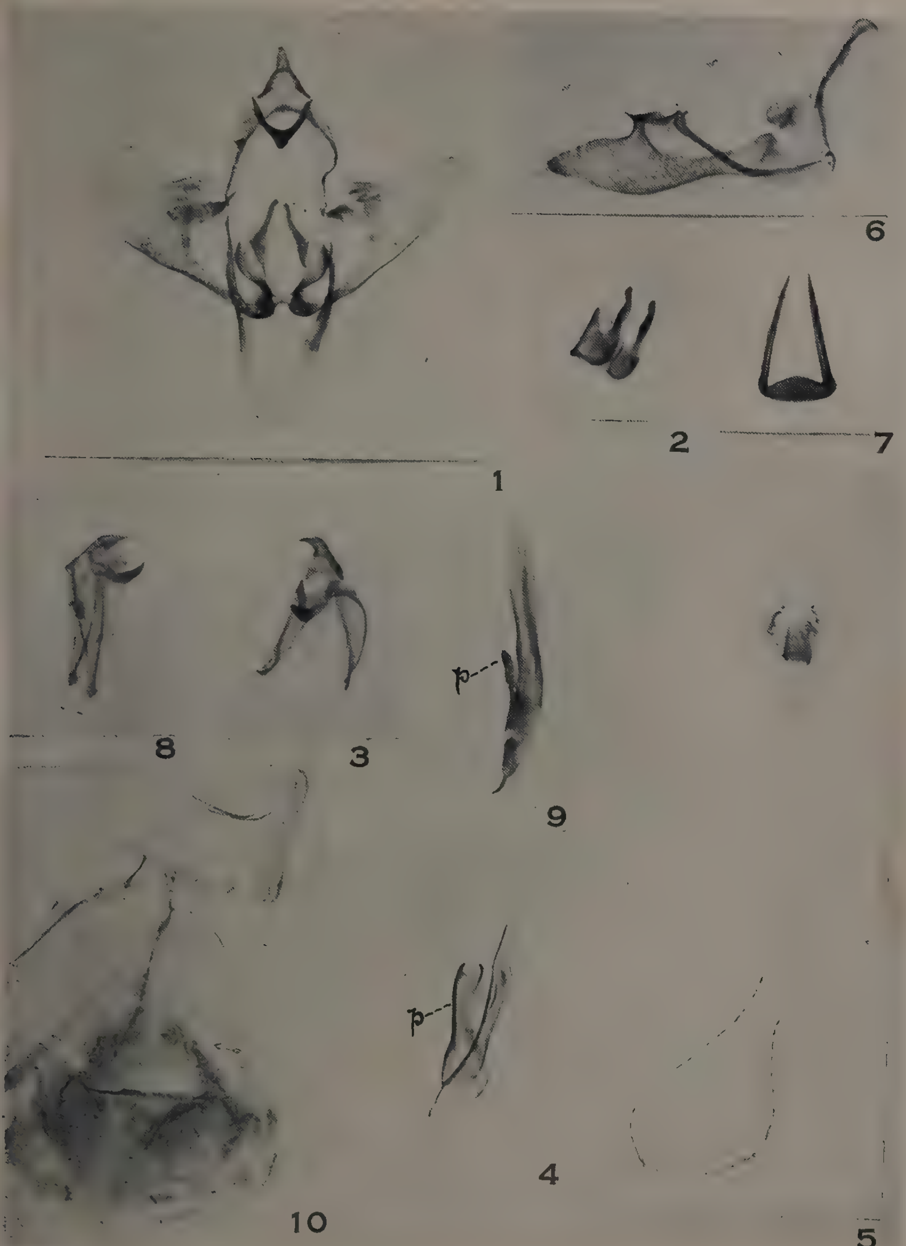

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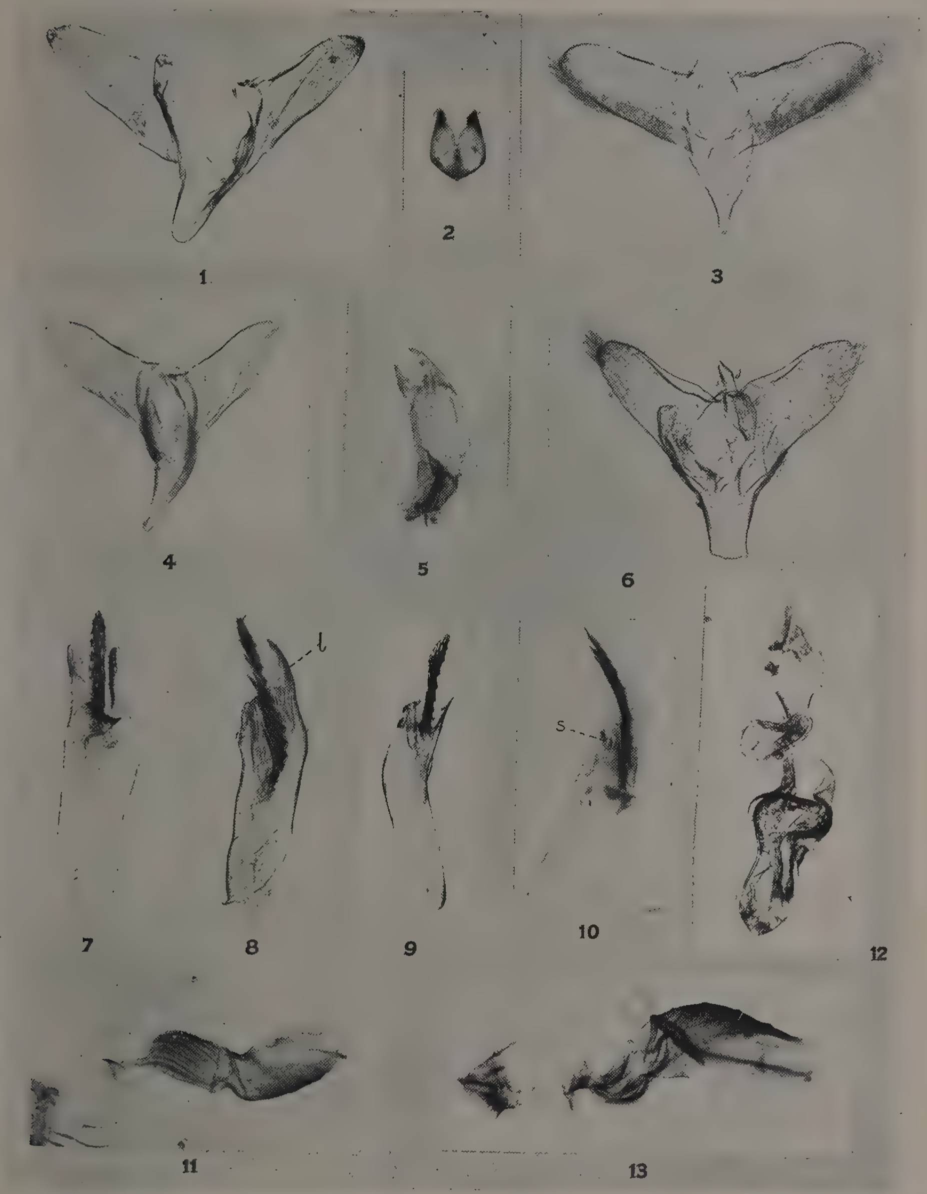

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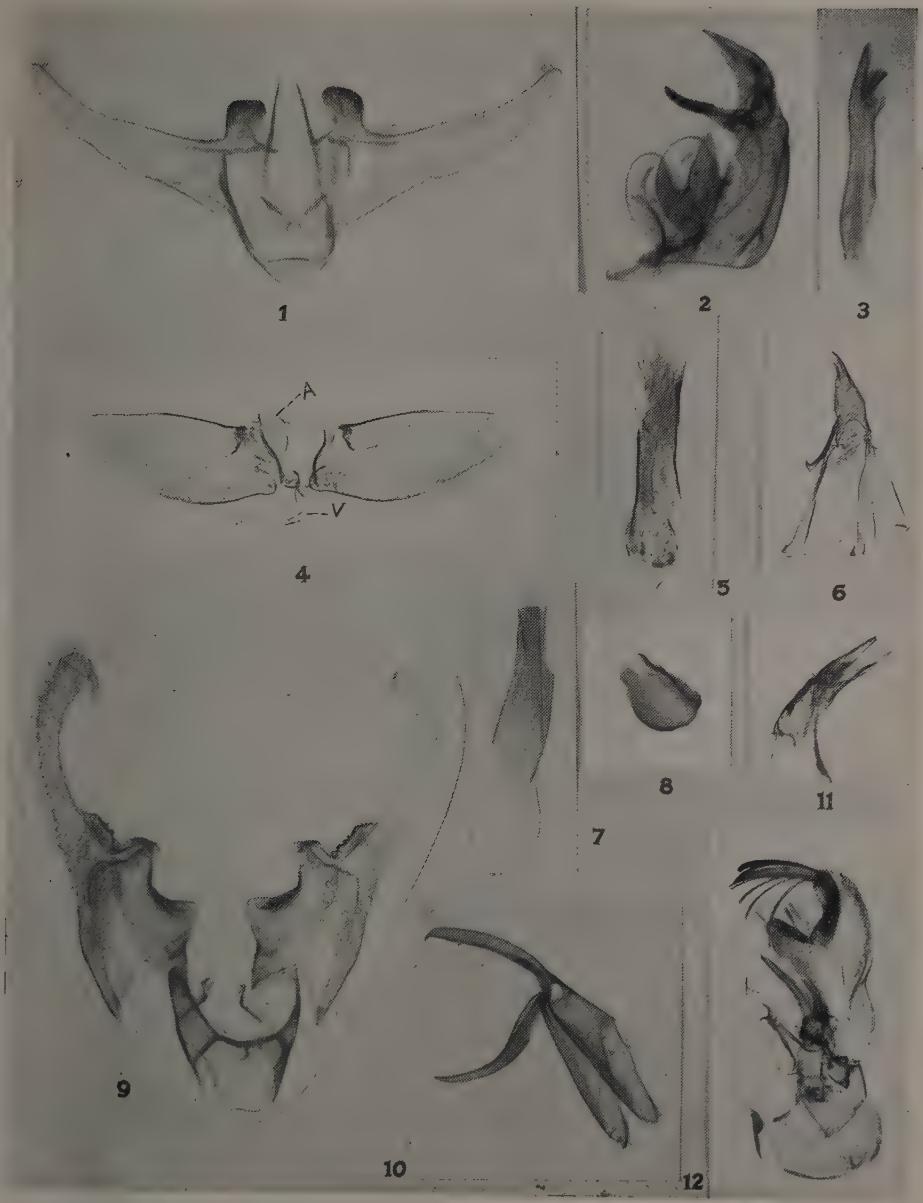

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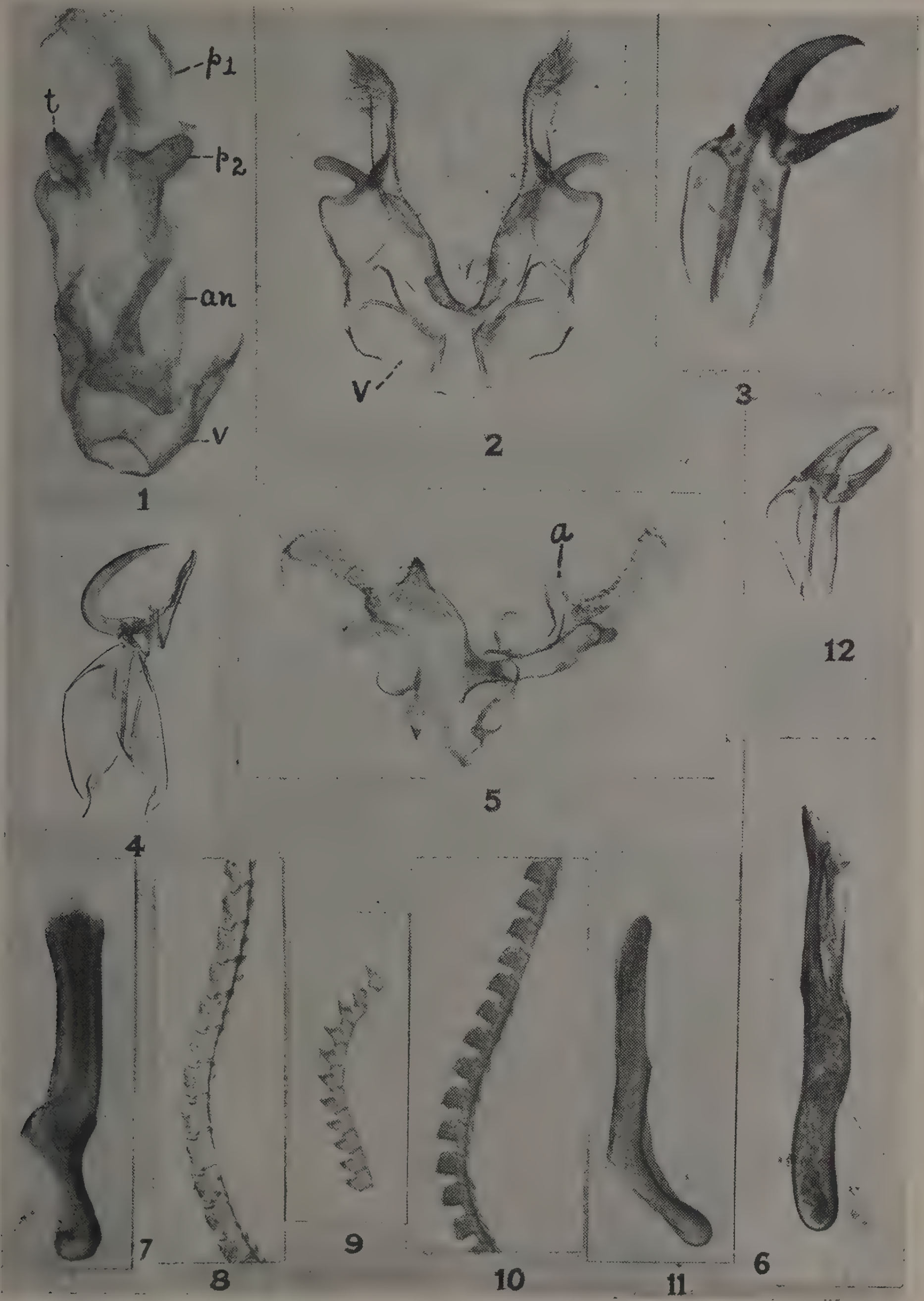

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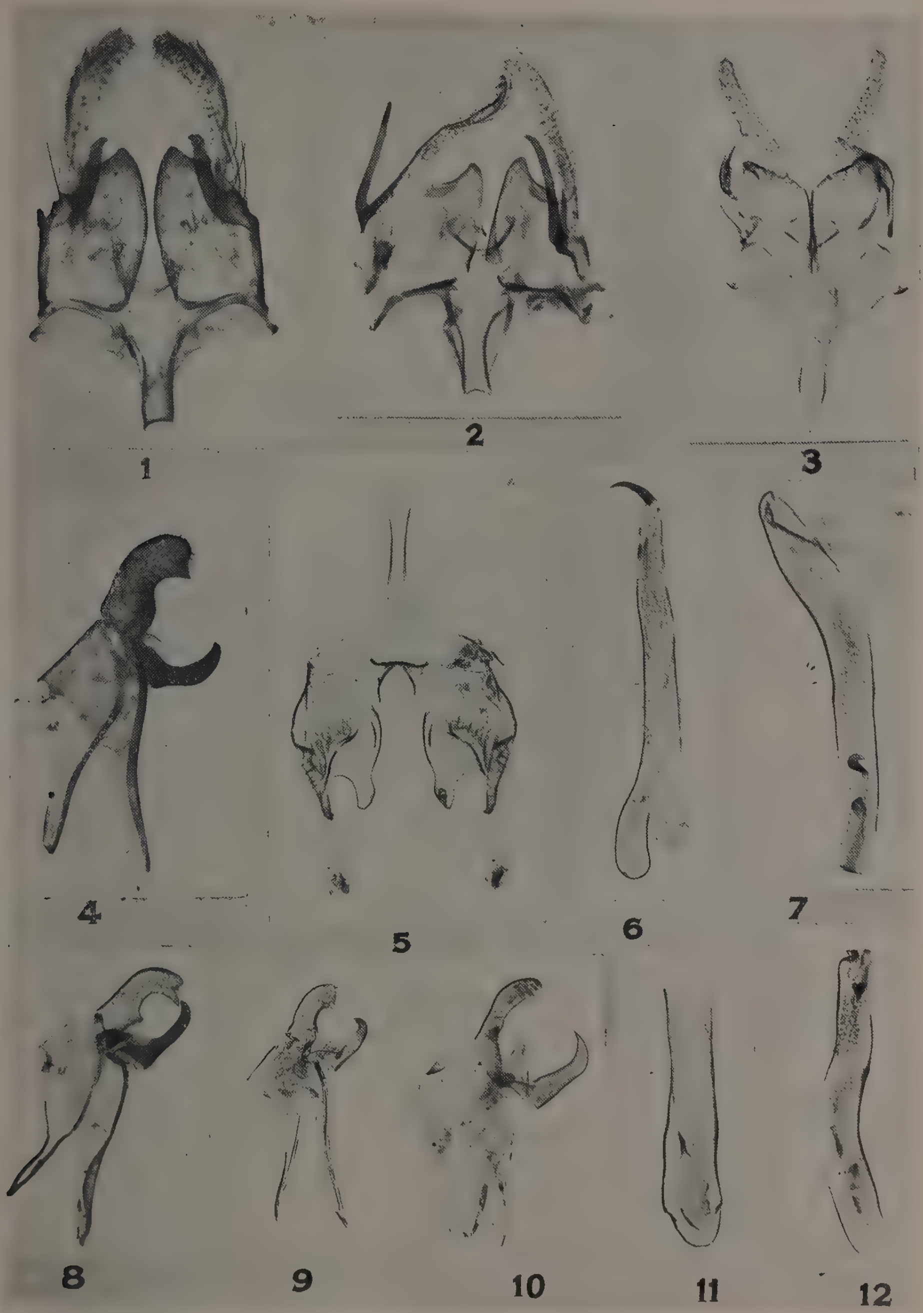
PLATE IX.



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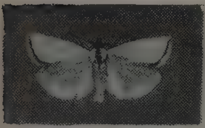
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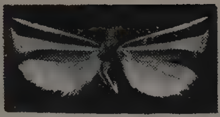
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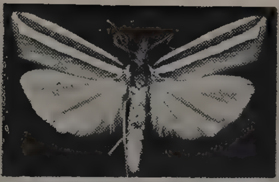
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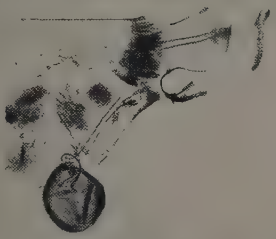
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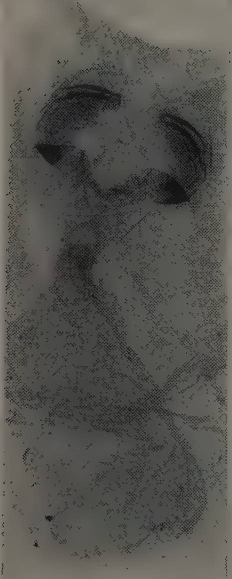
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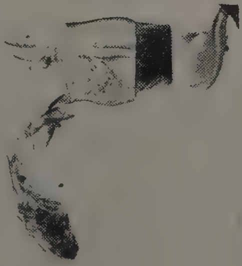
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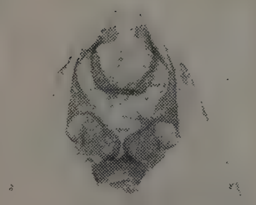
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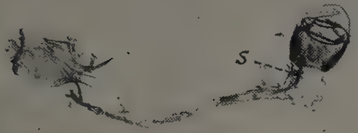

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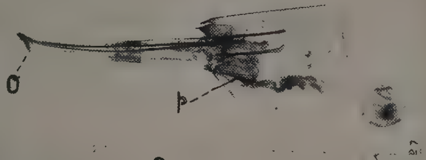

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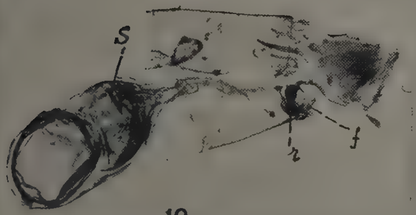

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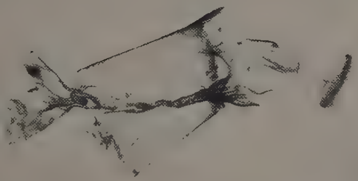
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A DESCRIPTIVE CATALOGUE OF THE PALAEARCTIC *EUPHYDRYAS* (LEPIDOPTERA : RHOPALOCERA).

By L. G. Higgins, M.A., F.R.C.S.

With 7 Maps and 41 Text-Figures.

Manuscript received 11th March, 1949.

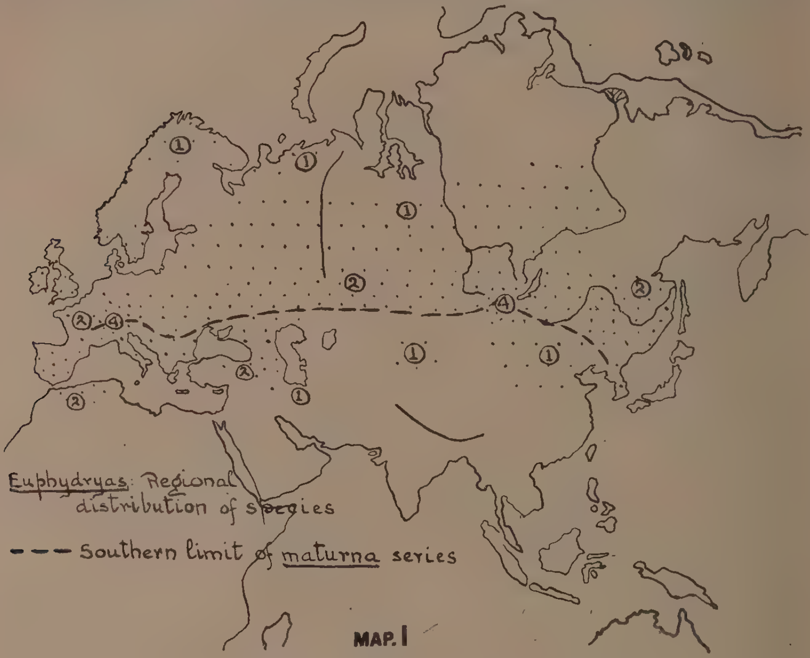
[Read 3rd May, 1950.]

This paper is to be read as a continuation of the Catalogue of the genus *Melitaea* published in these *Transactions* some years ago (1941, **91** : 175–365). On this occasion it is not possible to include coloured plates, and I am afraid that the paper will lose greatly by their omission. Fortunately most species and forms mentioned are quite well known, so that figures are less important than was the case with the *Melitaea*. I have to correct a small error relating to *Euphydryas* in the introductory pages of the first paper, inasmuch as it is found that *desfontainii* and *orientalis* are distinct species, although nearly allied. In the earlier paper, too, I did not realise the important differences which exist between the species of the *maturna* group and the *aurinia* series. These are possibly of generic rank, but the groups are small, and I have retained both in a single genus as usual.

EUPHYDRYAS Scudder. Distribution Map 1.

Euphydryas Scudder, 1871, *Syst. Rev. Amer. Butt.*: **27.** Type specified *Papilio phaeton* Drury.

The principal features of this group have been described in the Catalogue of *Melitaea* (p. 177), but it is convenient to recall here the main characters. The butterflies are more strongly built than is the case in other Melitaeine genera, and most of them can fly swiftly. The ground-colour on the upper surface is orange, yellow or rarely white, marked with black cross lines, orange macules and fasciae, and there is little variation among the species. The palpi (fig. 4) are hairy, strongly ascending with a short terminal joint. The male fore-leg is also hairy, the terminal joint (fig. 2) variable, but often single or with a short second joint (fig. 2a). Only in *desfontainii* is the fore-leg longer and commonly composed of two clear joints (fig. 39). In the female the fore-leg shows no special characters (fig. 3). The species are all single-brooded, and the life-histories of *maturna*, *cynthia* and *aurinia* are well known. The larvae show numerous long hairy spines (figs. 1, 5), and live when young on a family web. After hibernation, probably at the second instar, the family splits up and the larvae then live singly, sometimes with a complete change of food-plant. It is said that *desfontainii* does not hibernate, but feeds through the winter, at least in Algeria, after aestivation during the late summer heat (see p. 482). The known ova are cylindrical, flat on the top, with 18 or more longitudinal grooves which extend over half-way from the apex to base. This feature appears also in American forms, and is probably a generic character. The genitalia are most characteristic, and differ to an extraordinary degree from those of other Melitaeine butterflies. In the male they are very thick and horny, the tegumen little developed centrally, though from each side there arises a broad process which extends posteriorly and tapers rapidly to a point. The ventral extremities of the vinculae are held widely separate by a narrow bar, but the saccus proper is not developed. The ringwall is complete and tapers rapidly to a point posteriorly. The clasp is triangular or quadrilateral, truncated posteriorly, the tuberculated area provided with numerous teeth and bristles. The harpe is short and thick, directed medially, and provided with well-formed teeth. The penis suspended by its centre shows a relatively short distal limb. It is slightly curved from above downwards, and the strongly chitinised dorsal strip ends in a fine point which overhangs the ostium and supports the eversible membrane with its small morula. In the female the genital structure is very simple, and recalls the organ found in *Argynnis*. There is a large scutum which shows a boss on each side. Between these lies the orifice of the ductus bursae. A strong double bacillus supports the bursa copulatrix. This genus is not homogeneous, but is composed of two groups which must be considered separately. Although clearly allied and connected by many points of similarity, the two groups differ widely in certain biological features and especially in geographical distribution, and it seems doubtful to me whether they can be properly united in a single genus.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Euphydryas: Regional distribution of species
--- Southern limit of maturna series
MAP. I

MAP. 1.—Regional distribution of *Euphydryas* Scudder.

1. ***maturna*** group. Holarctic.

Palaearctic species.

1. *E. maturna* Linné.	3. *E. iduna* Dalman.
2. *E. intermedia* Ménétriés.	4. *E. cynthia* Schiffermuller.

Nearctic species. Gunder (see p. 486) defines 5 species as follows :—

5. *E. phaeton* Drury.	8. *E. editha* Boisduval.
6. *E. chalcedona* Doubleday & Hewitson.	9. *E. gillettii* Barnes.
7. *E. anicia* Doubleday & Hewitson.	

The Palaearctic species now reviewed are all closely related to one another and also to the American forms, and no atypical species is known. Specific features in the genitalia are not well marked, and may be vague. In the perfect insect the fore-wings are rather pointed, and nervure 10 usually arises on a short stalk with 9, but it may spring from the angle of the cell. On the upper surface the ground-colour is tawny, yellowish or white, with the usual orange macules and fasciae outlined by the black nervures and transverse lunules. On the under-surface the same pattern appears, but the markings are more delicate. A narrow orange fascia is present at the base of the hind-wing, but there are no black spots.

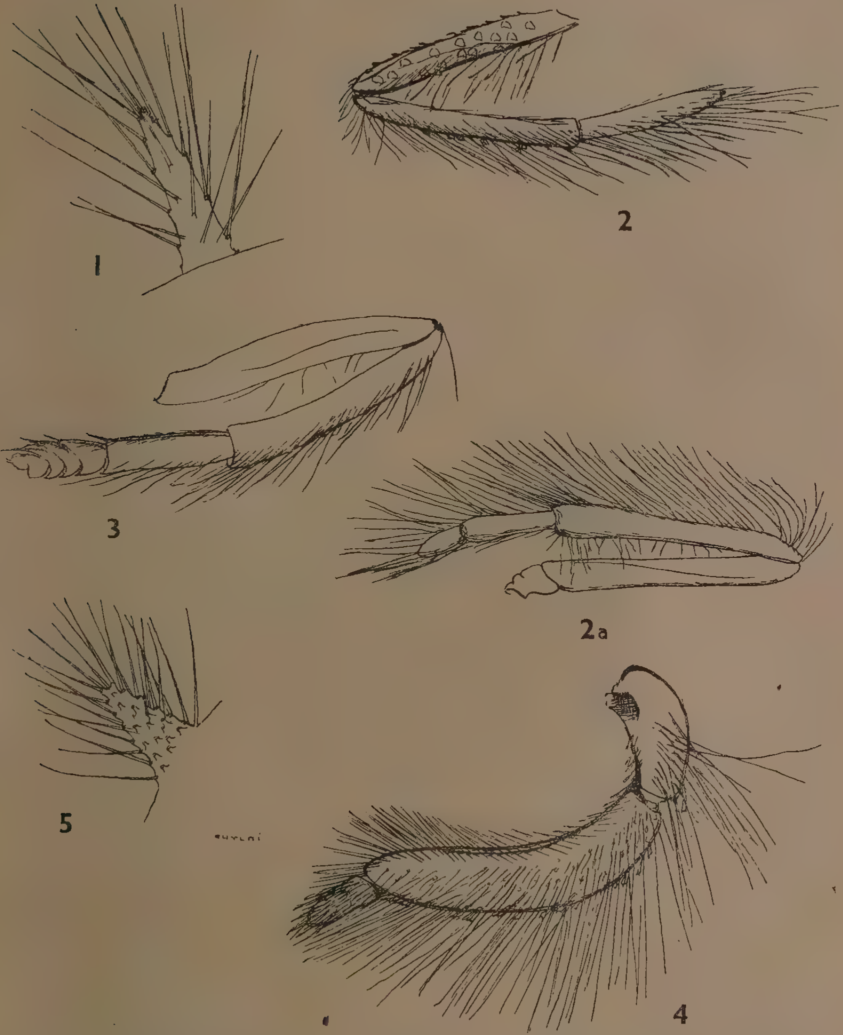
Distribution. This important group extends across Europe and Asia from Paris to the Pacific coast. It appears again in America in a series of forms which fly in the Rocky Mountains and western states, as far south as New Mexico and North Carolina, with one outlying representative in the eastern states (*E. phaeton* Drury). The species prefer cold or cool climates, and in Europe and Asia they rarely appear south of 50° north latitude. The genus is absent from the great mountains of central Asia, the Thian Shan, the Pamirs and from Thibet. It is the only group of Melitaeine butterflies which is represented in Asia and in America by closely allied and undoubtedly conspecific forms. The European species show little power of adaptation to unusual conditions and the customary climatic variation is not well marked. On the other hand, the American species seem much more variable and many geographical races have been described. It is an outstanding feature of the European forms that though the colonies may be widely separated, they yet cover an extensive distributional area. Although conditions seem ideal for promoting subspecific variation, this scarcely occurs, and the butterflies are remarkably stable. This picture of a few stable forms with extensive and discontinuous distribution is most unusual among Nymphalid butterflies. The group appears as a characteristic Siberian element, but it is interesting to note that the only species that is at all restricted to a narrow distribution area appears in the European Alps (*E. cynthia*) and no form is known that is peculiar to Asia. The four species which inhabit the Old World are all found in western Europe, and spread eastwards from there into western Siberia, and in one case further east to Korea. Each is rigidly confined to its chosen biotope. There is one arctic form, one is a forest dweller, another a typical butterfly of the high Alps, and the fourth is sub-alpine. None occurs in Britain, but *E. maturna* is found near Paris, in the Forest of Fontainebleu, and through Germany, Austria and Hungary to the Altai Mountains. It is a woodland form, peculiar to the deciduous forest belt, and always very local. There must be little chance of communication between the different colonies, which are often separated by many miles. *E. intermedia* Ménétriés is exceptionally interesting. It flies in isolated colonies in the southern European Alps, at sub-alpine levels among the pine trees. It appears again in the Altai and Sajan Mountains, and has a wide distribution eastwards through the Ussuri to Korea. Between the European habitat of *intermedia* and its nearest flight places in the Altai the distance is not less than 3000 miles. *E. iduna* Dalman shows a distribution which is even more bizarre. This species is widely spread in arctic Europe and probably in Asia also, very localised and often hard to find, but a vigorous colony will produce scores of specimens. It appears again as an alpine butterfly in the Sajan Mountains of southern Siberia, and far from any arctic habitat. Another colony has been discovered recently in the Caucasus, which is especially interesting in view of the known relationship between the Arctic fauna and the Caspian Sea. So far as I know, the distribution of *iduna* is unique among Lepidoptera. Lastly, the closely allied *E. cynthia* W.V. flies in the European Alps and in the Balkan Rhodope mountains. It is peculiar to Europe, and the habitat therefore is relatively restricted.

2. **aurinia** group. Palaearctic only.

1. *E. aurinia* Rottemburg.
2. *E. alexandrina* Staudinger.
3. *E. desfontainii* Godart.
4. *E. orientalis* Herrich-Schaeffer.

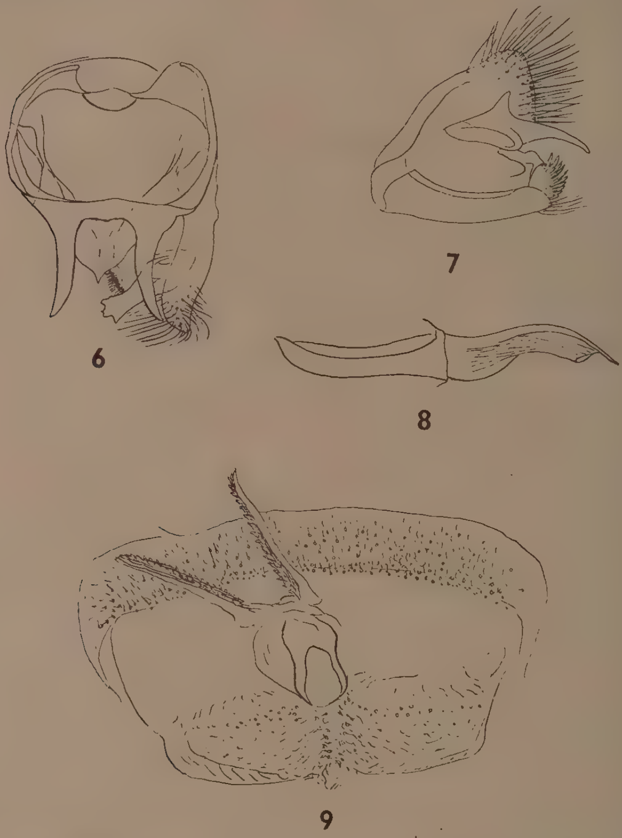
These butterflies differ from those of the *maturna* series in several small structural features. In the male genitalia the clasp is wider and more quadrilateral. The harpe is smaller and sickle-shaped with the convexity directed forwards. On the hind-wing the orange submarginal fascia is wide and shows characteristic black points in each cell, a feature which appears regularly only in *cynthia* in the *maturna* group. The larval spines (fig. 5) are shorter than those of *cynthia* and *maturna*. The biological characters of this group are well marked. There is a tendency towards modification into local races and subspecies. This is well seen in the vicariant forms *orientalis* and *desfontainii*, the latter showing at least three local races, and especially in *aurinia*, which presents such a confusion of subspecies, races and aberrational forms in its vast distribution area that an adequate analysis is very difficult. In addition, seasonal or climatic variation is well marked on lines which occur throughout the whole Melitaeine group. It is clear therefore that these butterflies have retained most pliable constitutions, susceptible to any modifying factors, in which respect this small but widely distributed group presents a strong contrast with the very stable butterflies of the *maturna* series.

Distribution. A general review of the geographical distribution of these insects may be made here. *E. aurinia* is common from the Atlantic coast of Ireland throughout central and southern Europe. It is found in Spain, northern Africa and the Caucasus, and eastwards from there through Siberia and Manchuria to Korea. This species does not appear in America. *E. desfontainii* flies in Spain and northern Africa, and a closely allied species, *orientalis*, appears in Asia Minor. This Mediterranean distribution recalls



FIGS. 1–5.—*Euphydryas maturna* L. 1. Larval spine; 2. Male fore-leg; 2a. *E. cynthia* W.V. Male fore-leg; 3. Female fore-leg; 4. Palpus, female; 5. *E. aurinia* Rott. Larval spine.

M. aetherie Hübner with an analogous range. Finally, *E. alexandrina* Staudinger is known as a mountain insect in the Alexander Mountains and western Thian Shan. This is the only species of the genus which is peculiar to Asia. The general geographical range of all these insects is centered much further south than is the case with *maturna* and its allies. The whole picture is of an eastern origin, and in this respect the connection with the *maturna* series seems rather distant. This suggestion is confirmed by the larval pattern. In *maturna* and *cynthia*, probably also in *intermedia*, the larvae are brightly coloured in yellow and black. In *aurinia*, *debilis* and *desfontainii* the larvae are known. They are all black with small white dots. There appears to be little specific differentiation, and the larval colour may well prove to be a group character.



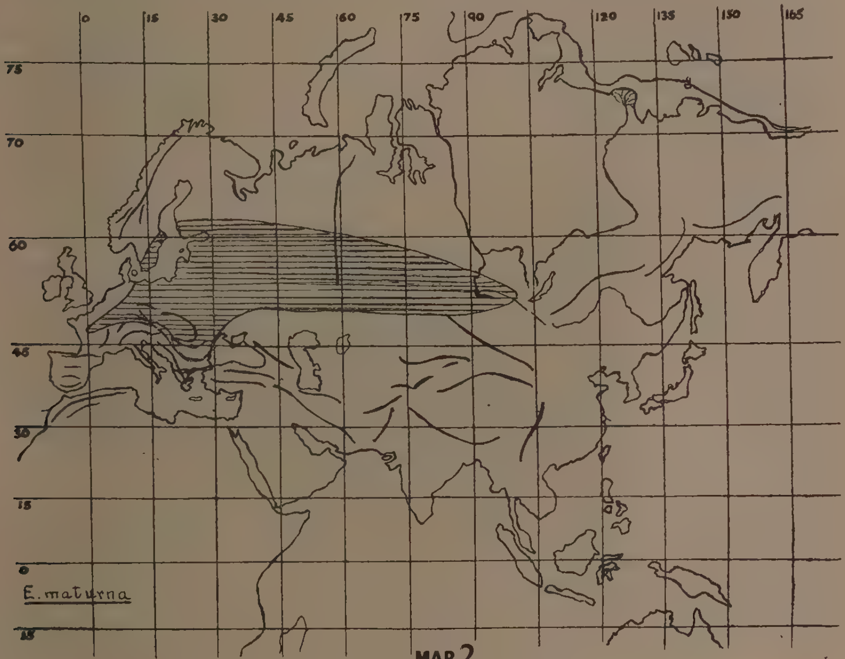
Figs. 6–9.—*Euphydryas maturna* L. 6. Male genitalia, dorsal view, right clasp removed; 7. Clasp, medial view; 8. Aedeagus. 9. Female genitalia.

EUPHYDRYAS MATURNA Linnaeus. Distribution Map 2.

Papilio maturna Linné, 1758, *Syst. Nat.* ed **10** : 480. No locality given.
Papilio agrotera Bergstrasser, 1780, *Nomencl. Ins.* **4** : 13. Loc. Leipsig.

Fore-wing ♂ 18–21 mm., ♀ 20–24 mm.

On the upper surface the base of the wing, the nervures and the usual transverse striae are heavily marked with black. The cellular marks and the submarginal macules of both wings are bright cinnamon-red. Other markings representing the ground-colour are paler, and the post-discal macules are usually yellow, making a conspicuous contrast, particularly the three large macules near the costa of the fore-wing. On the under surface of the fore-wing the markings are less distinct and the ground-colour is pale orange-brown. The rather large cellular stigmata are clearly seen, followed by three or four yellowish post-discal macules. The pale submarginal lunules with well-marked black proximal shading often tend to obsolescence. The series is slightly irregular, with lunule 3 displaced medially, as is the smaller mark in cellule 7, while that in 8 is a little oblique. On the hind-wing the markings are very beautiful, with strongly contrasting bands of yellow and bright orange-red. The post-discal striae are generally present, placed in the centre of the post-discal area. The submarginal lunules are distinctly bordered proximally with black. An orange-red border is present along the extreme outer margin of both wings. The female is slightly larger than the male, and on the upper surface the colour contrast is often less marked.



Map 2.—Distribution of *E. maturna.*

The male genitalia (fig. 6) closely resemble those of *intermedia* and *cynthia*. The vinculae are not so widely separated and the subuncal processes are a little longer and more slender. The lateral view of the clasp (fig. 7) shows the harpe is a good deal longer than in related Palaearctic species, and there is no marked dentate crest on the posterior cornu. The penis (fig. 8) is not distinctive. The female genitalia (fig. 9) show a wide genital plate, of which the central part is bare of seta pits—a striking character. There is a short and wide antrum which carries a pair of strong bacilli, provided internally with a series of small teeth.

The early stages are well known. The yellow oval egg is grooved near the summit and is figured by Goossens (*Ann. Soc. ent. Fr.* **1884**, Pl. 5, fig. 38). The larva is yellow with dark longitudinal and finer transverse stripes. The larval spines are long (fig. 1). It was figured by Capieux as long ago as 1778 (*Naturforscher*, **12** : 68) with the pupa. In the early instars it is said to feed upon various low plants, including *Scabious*, *Salvia*, *Plantago*, etc., but after hibernation it changes its food-plant and occurs on *Populus tremula*, and more rarely upon *Populus alba*, willows and privet.

Variation and distribution. In this species variation is chiefly restricted to individual aberrations with fusion or distortion of the usual markings. These aberrations are commonest in the female and many striking forms have been described. There is little tendency to the formation of local races, and the butterfly does not appear sensitive to ecological conditions. There is described as var. *urbani* Hirschke (1901, *Jber. Wien ent. Ver.* **11** : 85) a form from the Salzachtal in which the black pattern is more extensive than usual. Such specimens occur in many localities among typical specimens, and represent the extreme limit of normal variation. From Bosnia a local race has been described by Fruhstorfer as *M. maturna idunides* (see below), in which the ground-colour of both wings is nearly white. I have not seen specimens of this form, which is referred to the eastern *staudingeri* by Rebel. If the insects are really similar, *idunides* (1917) will take precedence over *staudingeri* (1929) as the correct name for the eastern race.

The insect is distributed from the neighbourhood of Paris eastwards across temperate Europe. In the west it is very sporadic and entirely absent from large districts. Further east it is much more general in Austria and Hungary. The insect occurs chiefly in wooded country at low elevations. It extends across Russia and western Siberia, including the Urals to the Altai Mountains. It is probably absent from the Caucasus. Eastern specimens are slightly modified, and appear in the form *staudingeri* described below.

Localities :—France : only in the north ; very local. Germany : commonest in the south. Sweden and Finland : not common ; only in the south. Austria and Hungary : common ; recorded also from Bosnia, Croatia, Herzegowina, Rumania, Dalmatia and Banat. Russia : throughout the temperate region, extending across western Siberia.

Euphydryas maturna mod. ***staudingeri*** Wnukowsky.

M. maturna uralensis Staudinger, 1871, *Cat.* (Ed. 2) : 17, nec *M. arduinna* var. *uralensis* Eversmann, 1844, *Faun. Ural.* : 3.

M. maturna staudingeri Wnukowsky, 1929, *Zool. Anz.* **83** : 221. Nom. nov. pro *uralensis* Staudinger, preocc.

M. maturna idunides Fruhstorfer, 1916 (1917), *Arch. Naturg.* **82** (A) (2) : 3. Loc. Bosnia.

Fore-wing ♂ 17–18 mm., ♀ 18–20 mm.

This is usually smaller than the typical form. The pale ground-colour on the upper surface is often nearly white and the colour contrast is very bright. This form is well marked in most eastern specimens. The smallest I have seen are from the Altai Mountains ; the altitude is not specified, but Staudinger reports the insect in these mountains flying at a considerable height. In the Ala Tau I have a record of 1500 m. In these specimens the *staudingeri* characters are very marked. The form taken in Europe in Bosnia on the Maklen Pass, at about 3000 ft., is very similar if not identical (*idunides* Fruhst.). It seems possible that this modification appears at relatively high altitudes, in which case it should be classed as *forma tempestatis*.

Localities :—DZUNGARIAN ALA-TAU : Lepsinsk 1500 m., July (coll. L.G.H.). ALTAI MOUNTAINS : Ust-Kansk ; Korgon Mt., July. URALS : *fide* Staudinger. No specimens seen.

The following aberrations of *maturna* have been named :—

M. maturna ab. *fulgida* Schultz, 1908, *Ent. Z.* **22** : 90. Loc. Vienna. The dark markings are shot with blue.

M. maturna ab. *schlumbergeri* Schultz, 1907, *Ent. Z.* **20** : 279. Loc. Austria. A dark form with distorted pattern.

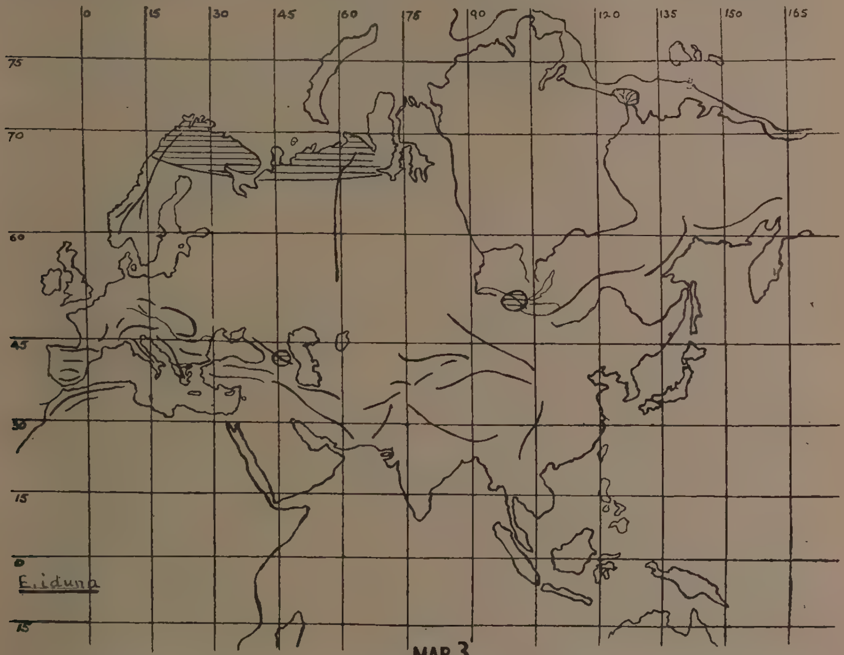
M. maturna ab. *diabolus* Schawerda, 1914, *Verh. zool.-bot. Ges. Wien* **64** : 352. Loc. Bosnia and Herzgowina. The pale macules obliterated by extension of the black pattern.

M. maturna ab. *kautzi* Schawerda, 1913, *Verh. zool.-bot. Ges. Wien* **63** : 146. Loc. Herzgowina (Vucijabara). A form of *staudingeri* with distorted wing pattern.

Note. *M. maturna altaica* Seitz, 1907, *Grossschmett. Erde* **1** : 212, is referable to *intermedia* Ménétriés and does not refer to *maturna* L.

EUPHYDRYAS IDUNA Dalman. Distribution Map 3.

M. iduna Dalman, 1816, *K. Vet. Ac. Hand.* **1** : 75. Loc. Sweden.
M. iduna sajana Bang-Haas, nom. nud. ?, 1930, Seitz. *Suppl.* **1** : 204. No locality given.
M. iduna inexpectata Sheljuzhko, 1934, *Z. Ost. ent. Ver.* **19** : 30, figs. Loc. Caucasus.

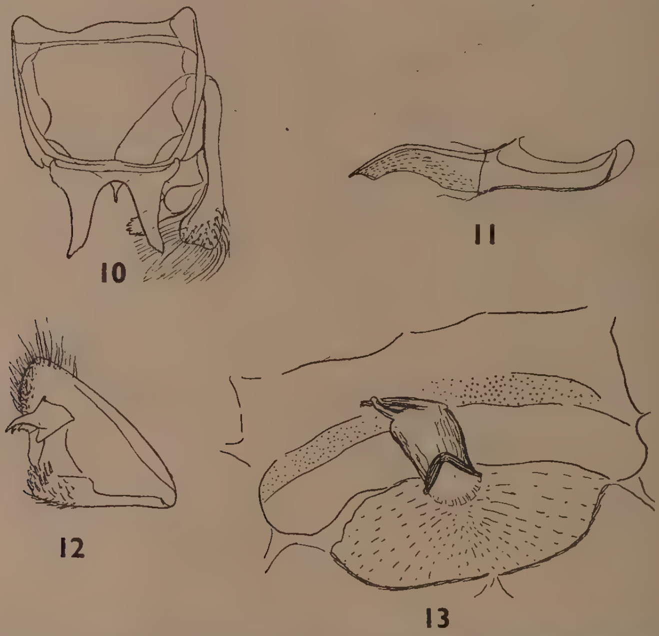


MAP 3

MAP 3.—*E. iduna*, showing known Arctic distribution, with islands in Sajan Mountains and the Caucasus.

Fore-wing ♂ 15–18 mm., ♀ 18–21 mm.

On the upper surface the ground-colour of the wings is white, tinged with yellowish-grey. The wing-bases, nervures and the transverse striae are marked with black. The cellular marks and submarginal fascia are dull orange, and there is a narrow marginal border of the same colour. The hind-wings show the same colour scheme, with a wide black area along the body fold. On the under surface the pattern is repeated, but all the black markings are more delicate, and consequently the white ground-colour appears to be more extensive. There are often indications of yellow centres to the anterior macules of the orange submarginal fascia of the fore-wings, and the orange terminal border is very distinct. The palpi and legs are orange-red. The wings give the impression of being thinly scaled. The female is slightly larger and often paler than the male, but the markings are similar.



Figs. 10–13.—*Euphydryas iduna* Dalman. 10. Male genitalia, dorsal view, right clasp removed; 11. Aedeagus; 12. Clasp, medial view; 13. Female genitalia.

The male genitalia (fig. 10) closely resemble those of *cynthia* and *intermedia*. The vinculae are widely separated, and the subuncal processes are a little shorter and wider than in *maturna*. The clasp (fig. 12) is triangular in lateral view, with the usual brush of strong spines at the inferior posterior angle. The harpe is prominent, sickle-shaped, with a comb of teeth along the concave lower border. Seen from above it is extended obliquely inwards and backwards, with the small spines turned upwards like the fingers of a hand. The penis (fig. 11) resembles that of other members of the group. The female genitalia (fig. 13) are somewhat compressed but wide, the naked area narrow. A short and wide antrum is present, which shows a V-shaped margin as it opens into the ostium, which is not quite visible. The bacilli are short, possibly broken or distorted in the specimen examined.

Variation and distribution. In this insect there is minor variation in size and in the extent of the black scaling on the upper surface. In the paler specimens all orange macules are larger; in the darker specimens they are more or less obliterated by the wider black lines (ab.*sulitelmica* Schultz (1906/07, *Ent. Z. Guben* **20** : 272)). These minor variations are individual, and I have never seen the aberrations and distorted wing-patterns which appear so commonly in related species. The butterfly is unusually stable, and I can detect no variation of geographical importance. It was described from Lapland, where it appears at low or moderate elevations, up to about 2000 ft. in mountains. The colonies are excessively localised, but often abundant in individuals. It is one of the first insects to appear when the snow melts, often early in June, but the date of emergence varies with the locality. In Europe it is known from Norway, Sweden and Finland, and no doubt it occurs also in Arctic Russia, but it is not known how far to the east the range extends. The butterfly appears again in the Altai and Sajan Mountains as an alpine insect, flying here at about 6000 ft. I have seen considerable series from both these localities. Some of these are curiously pale, described below as *sajana.* Rühl also gives the Tarbagatai Mountains, but this needs confirmation. More recently the insect has been reported from the Caucasus, where it was taken flying at a great height. Sheljuzhko recorded three specimens, and separated them as a subspecies which he named *inexpectata.* Judging from the figures which were published with the original description, there are few features distinguishing these examples from the typical form, and the racial distinction requires confirmation. The relative absence of variation in spite of prolonged isolation in these different regions shows the extraordinary stability of the butterflies of this group.

Euphydryas iduna mod. ***sajana*** mod. nova.

In this form the wings look more thinly scaled and the black markings are reduced. On the fore wing the discal series of black macules may disappear altogether, exposing the white ground-colour.

In such extreme specimens the white submarginal macules are often enlarged. On the under surface of both wings the usual black nervures are less obvious and the whole insect looks pale.

In a series from the Sajan Mountains—the Tunkinsk Weissberge—about half the individuals could be placed as *sajana*, the rest are quite normal specimens indistinguishable from Scandinavian examples. Two small specimens taken by Elwes in the south-eastern Altai Mountains should be placed here. A long series in the British Museum from Tchuja Mts. shows the same features. I have not seen this form from Europe.

The name *sajana* was introduced by Dr. Bang-Haas in 1930, but was then *nomen nudum.* It is quite possible that this name has already appeared in the literature, so I think it is best to give it a definite meaning.

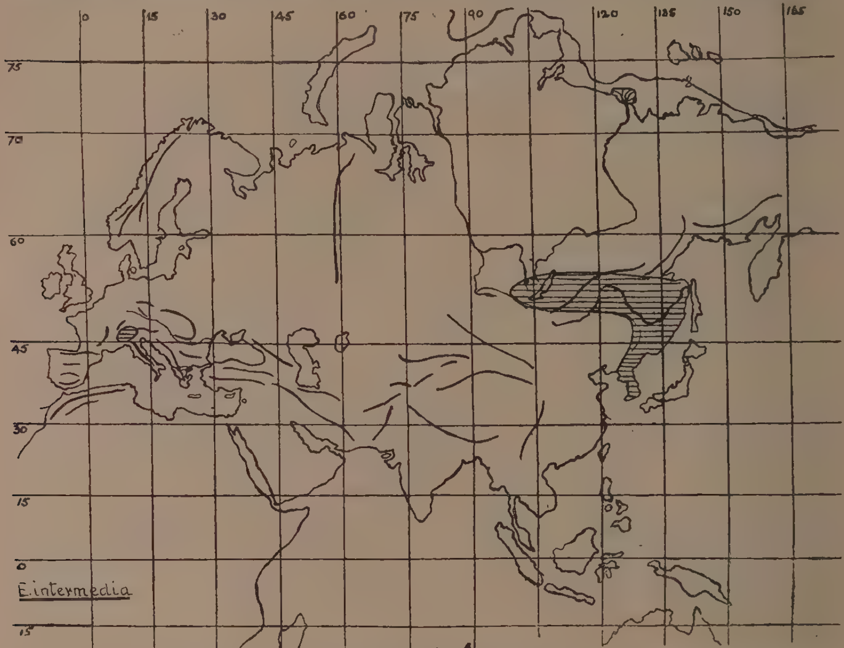
Localities :—SWEDEN : Abisko, various dates, 18 June–23 July ; Quickjokk, no date. NORWAY : Lule, no date ; Saltdalen, 16 July ; Porsanger Fiord, no date ; Maalselvdal, July (Haig-Thomas Coll.) ; FINLAND : many localities, Enontekio ; Ylaluostari ; Kilpisjarvi ; etc. Good information is given by K. J. Valle in 1935, *Ann. zool. Soc. Zool.-Bot. Fenn.* **1** : 117 (German). ALTAI : Tchuja Mountains, July, 1898 (H. J. Elwes coll.). SAJAN : (Irkutsk) Tunkinsk Weissberge, 2000 ft., July. CAUCASUS (*fide* Sheljuzhko).

EUPHYDRYAS INTERMEDIA Ménétriés. Distribution Map 4.

M. maturna var. *intermedia* Ménétriés, 1859, *Schrenk's Amur Reise* 2 (Lepidopt.): 22. Loc. Khotum—Amur.
M. ichnea auct. *nec* Boisduval, 1833.
M. maturna var. *mongolica* Staudinger, 1892, *Iris* 5 : 321. Loc. Kentei.
M. maturna altaica Seitz, 1909, *Grossschm. Erde* 1 : 212. Loc. Altai.

Fore-wing ♂ 18–20 mm., ♀ 20–23 mm.

On the upper surface in the male the ground-colour of the wings is orange-yellow, with all nervures clearly but finely marked in black. On the fore-wing the usual pattern is present and complete. The stigmata in the cell are filled with slightly deeper orange. Sometimes there are some paler yellowish scales near the costa, posterior to the black discal bar. A fine black line is present immediately before the outer margin. On the hind-wing the discal fascia is seen as a darker orange horse-shoe-shaped mark, enclosing a paler rounder spot. Not uncommonly the post-discal macules are of a paler tone than the rest of the wing. The orange submarginal fascia is again darker, and very small black pupils are often present, most commonly in the macules of cellules 3 and 4. The outer margin is usually suffused with black scales. The general effect is uniform orange with a black pattern and little colour contrast. On the under surface the ground-colour of the fore-wings is paler orange-yellow, the nervures and transverse lines clearly but finely marked in black. The macules in the cell and the marginal lunules are filled with yellow, and the same colour appears near the costa in the post-discal and submarginal lunules. The cellular marks and the outer-marginal border are darker orange. On the

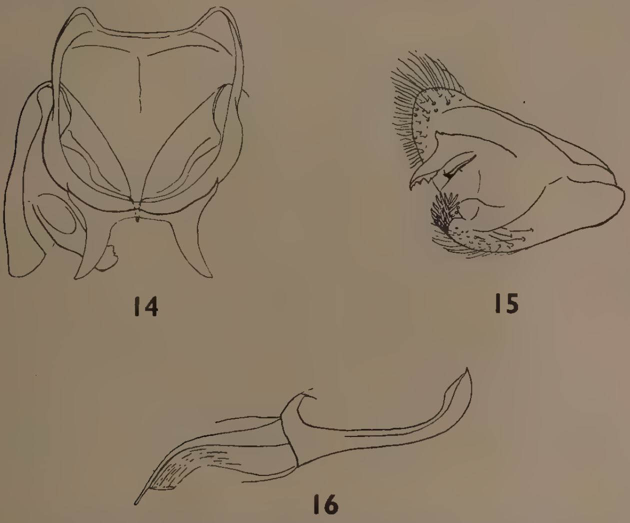


MAP.4

Map 4.—*E. intermedia*, showing extensive Asiatic distribution area and restricted range in European Alps.

hind-wings the ground-colour is paler yellow, the nervures clearly marked with black. The basal, discal and submarginal fasciae, and the outer-marginal border, are a uniform deeper orange. Small black points, often lying in a yellowish eye, are usually present in the submarginal fascia. In many specimens fine transverse striae, representing the discal spots, may be seen in the yellow post-discal fascia. The female resembles the male, but is often larger and the fore-wings are rounder and more ample. The early stages have not been described accurately. Staudinger stated that larvae were found in May near Vladivostok, feeding upon *Lonicera*, and they closely resembled those of *maturna* (1892, Romanoff, *Mém. Lép.* **6** : 181).

The genitalia of the male (fig. 14) show the vinculi widely separated. The tegumen is narrow, the lateral processes short and wide. The clasp is triangular as in *maturna*, but the harpe is shorter (fig. 15), the dorsal spine less prominent, and a series of teeth is present along the lower margin. The penis (fig. 16) is not distinctive, and the whole organ is scarcely separable from that of *cynthia* and *iduna*. The female genitalia are of the usual pattern, and certainly less wide than in *maturna*.



Figs. 14–16.—*Euphydryas intermedia* Ménétriés. 14. Male genitalia, dorsal view, right clasp removed; 15. Clasp, medial view; 16. Aedeagus.

Variation and distribution. This very stable species shows only slight variation in the extent of the black markings on the upper surface. The small black points in the submarginal fascia of the hind-wings may be absent. On the under surface there is a good deal of variation in the extent of the black transverse markings. These may be nearly absent, in which case the fine black striae in the post-discal area of the hind-wings are usually wanting. The typical subspecies is known to occur from the eastern Altai Mountains to the Pacific. At least in the western range it appears as a sub-alpine insect, although records of altitude are rare. In this part of its range it is associated with *maturna* L., and the two species have been recorded flying together in the Kentei Mountains (Staudinger in 1892, *Iris*, 5 : 321). Towards the east the insect attains a larger size to reach a maximum development in Korea, in the form *konumensis* Matsumura. In this region it is possible that the butterfly occurs at lower altitudes.

Localities :—ALTAI MOUNTAINS : Ogodai 3000–5000 ft., 28 May ; 14 June (Elwes). KENTEI MOUNTAINS : no further data (Staudinger). SAJAN MOUNTAINS : Charborowfka, Tunkin Sajan ; Tunkinsk Weissberge, July, 2000 m. (East Sajan). KOREA : Sutschanski Rudnik (*konumensis* Matsumura). KAMSCHATKA : no further data.

Euphydryas intermedia mod. *konumensis* Matsumura.

M. maturna var. *konumensis* Matsumura, 1927, *Ins. Mats.* 2 : 117, Pl. 3, fig. 5 *o.*, Loc. Saghalien, July, 1927.

Fore-wing ♂ 25–27 mm., ♀ ? mm.

This is much larger than the typical eastern form. On the upper surface the submarginal fasciae are wide, but show little contrast with the orange-brown ground-colour. East of the Sajan Mountains the costal macule of the discal series is commonly more obliquely placed as it joins the costa. This form has been seen only from the most eastern districts of the distribution zone, and grades insensibly into typical specimens.

Euphydryas intermedia wolfensbergeri Frey.

M. maturna wolfensbergeri Frey, 1880, *Lep. Schweiz.* : 27. Loc. Southern Alps of Europe.

Fore-wing ♂ 22 mm., ♀ 24 mm.

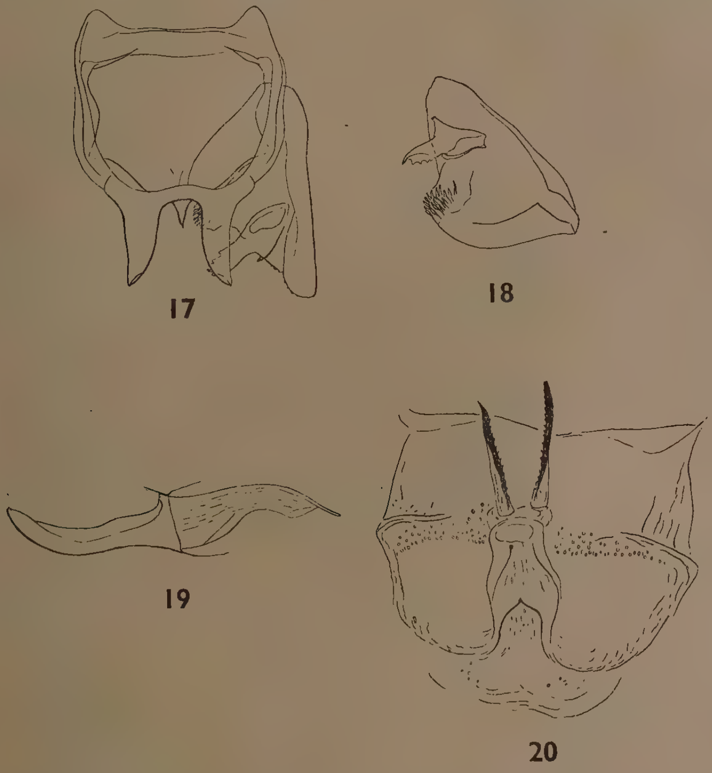
On the upper surface in both sexes the fore-wings are rather pointed. It is not easy to compare the wing-colours as my series of *wolfensbergeri* is fresh, while most available *intermedia* are old. In the former on the upper surface it appears that the general tone is brighter and redder, especially the cellular marks and the submarginal fasciae. The latter are usually slightly narrower in *intermedia*. On the hind-wings the post-discal spots are frequently yellowish or even white. On the under surface of the hind-wing the orange basal and discal fasciae are often very narrow. In the submarginal fascia traces of black points are common, present (distinctly) in 8 of my series of 40 specimens.

There appears to be no published description of the ovum, larva or pupa of this form.

The genitalia (figs. 17–20) resemble those of typical *intermedia*.

Minor variation is on the same lines as in typical *intermedia*, with which *wolfensbergeri* agrees so closely that it is doubtful whether any subspecific distinction can be maintained. The insect occurs in the southern Alps from the Corniche Alps to the Saas Tal in western Switzerland. It is an extremely local butterfly. The flight places occur near the upper tree level, at an altitude of 5000–6000 ft., but it may appear as low as 3000 ft. exceptionally. It is especially widespread in the Engadin, where it penetrates to the Silvretta and also to the Oetz Thal. It is a difficult insect to see, easily overlooked, and probably much less rare than is now thought. It seems often closely associated with *Brenthis thore* Hb. The distribution areas of the western and eastern forms show a remarkable gap across Russia and western Siberia, and they are now separated by over 3000 miles. It may be that some records of *maturna* from western Siberia refer to this insect, but this is not very likely as there are no mountains in this region.

Determination of *wolfensbergeri* is not always easy. In the Alps it is often closely associated with *cynthia*, although the latter is an Alpine insect, and the two never occur upon the same ground. In the cabinet the female of *cynthia* can only be separated with difficulty from *wolfensbergeri.* On the upper surface the black shading is less diffuse. On the under surface in *cynthia* the yellow macules of the hind-wings are duller and contrast is less marked, while there is a firm dark line internal to the orange submarginal fascia which does not appear in *wolfensbergeri*, in which the line is no stronger than the other markings of the wing. The distinction from *maturna* is less difficult. On the upper surface in the latter the orange cellular marks are wider and larger in both wings. There is greater colour-contrast and the post-discal macules are usually yellow. The submarginal lunules are often narrow, those at the apex of the fore-wing small and displaced medially. On the under surface also there is greater contrast. The orange cellular marks are conspicuously wide. The submarginal lunules are narrow and often irregular, particularly on the fore-wing. As *E. maturna* is a lowland insect there can be no confusion in the field.



Figs. 17–20.—*Euphydryas intermedia wolfensbergeri* Frey. 17. Male genitalia, dorsal view, left clasp removed; 18. Clasp, medial view; 19. Aedeagus; 20. Female genitalia.

Localities :—Italy : Dolomites ; Sarn Thal ; Alpi Carniche, Sappada

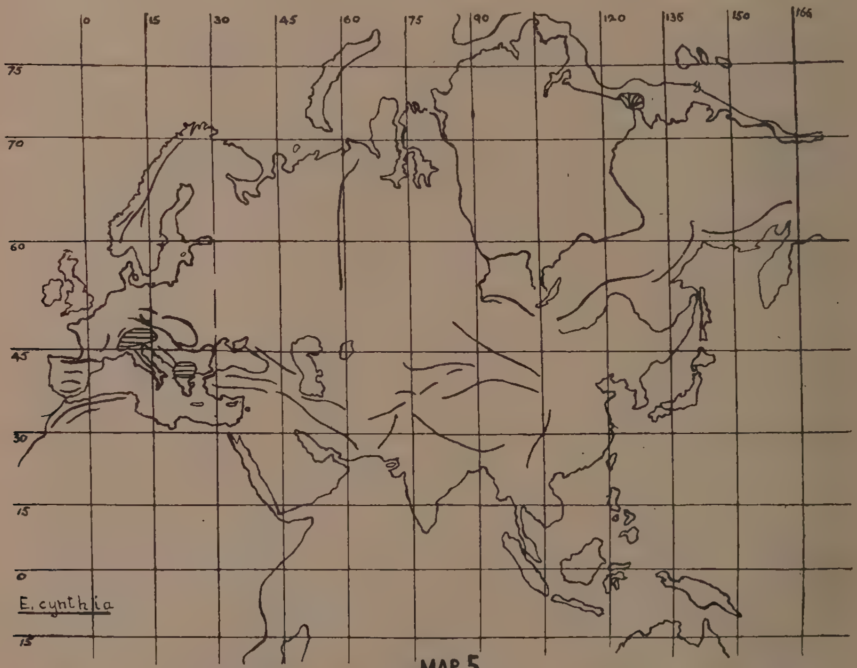
1600 m., 10 July (Luigi Rocca, 1938, *Mem. Soc. ent. Ital.* **16** : 124). AUSTRIA : Oetz Thal, Wisp Thal. SWITZERLAND : Davos ; Engadin, frequent colonies ; Val Anniviers ; Saas Fee.

N.B. *Melitaea ichnea* Boisduval. It is not possible to determine the species from the description. The figure shows unmistakably a female of *cynthia*, of the Austrian form, and to this insect the name should be applied. Lederer (*Verh. zool.-bot. Ges. Wien* **2** : 40) agrees there can be no distinction from *cynthia*. The locality given, "Lapland and northern Siberia," cannot refer to the insect figured.

EUPHYDRYAS CYNTHIA Schiffermuller. Distribution Map 5.

Papilio cynthia Schiffermuller, 1775, *Syst. Verz.* : 179. Loc. Austria.
Papilio mysia Hübner, 1800, *Samml. europ. Schmett., Papilio* : 5, figs. 1, 2. Loc. Austria, Styria, Carinthia, Tirol.
M. ichnea Boisduval, 1833, *Icones.* 1 : 112. Loc. "Lapland and Siberia."

Note. It is unfortunate that the name *cynthia* in the *Wiener Verzeichniss* is not probably referable to the insect now described, but nearly certainly to *maturna* L. I think the name should be retained with its customary meaning as *nomen conservandum*, and have used it here. Hübner's *mysia* certainly represents the same form, and probably also *ichnea* of Boisduval. Both these synonyms are valid and available if required.

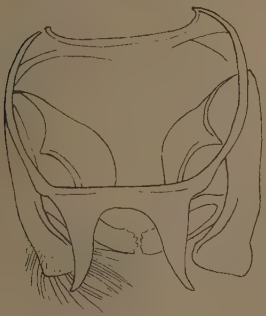


MAP. 5

MAP 5.—*E. cynthia*, showing discontinuous areas of distribution in European Alps and Balkan Mountains.

Fore-wing ♂ 22–25 mm., ♀ 25–28 mm.

In the male on the upper surface the ground-colour is milky white, with the usual black transverse striae and markings along the nervures. The cellular macules and the submarginal macules on both wings are orange-red. The latter on the hind-wings show a black point in each macule. The marginal lunules are often red, and sometimes whitish or smoky. On the under surface the colours are more subdued, with the ground-colour yellowish-white. On the fore-wings the black markings are scarcely developed, the cellular macules are bright orange-red, finely outlined with black. On the hind-wings all nervures and markings are outlined with black, which forms a bold internal border to the orange-red submarginal macules. The female is quite a different insect, showing the same type of sexual dimorphism seen in *M. romanovi* Gr. The ground-colour is orange brown with heavy black markings, and a fascia before the submarginal macules is especially prominent. On the under surface the difference between the sexes is less marked.



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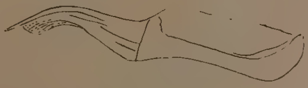

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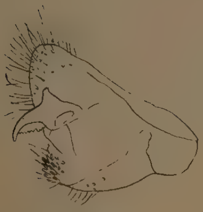

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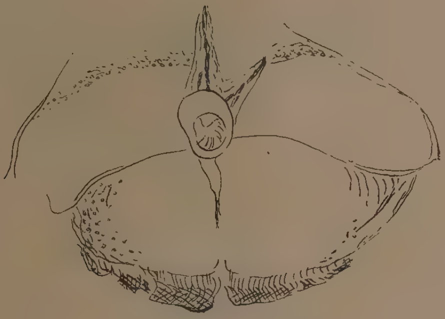

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Figs. 21–24.—*Euphydryas cynthia* W.V. 21. Male genitalia, dorsal view; 22. Clasp, medial view; 23. Aedeagus; 24. Female genitalia.

The male genitalia (fig. 21) resemble those of *intermedia* and *iduna* very closely. In lateral view the harpe is somewhat shorter (fig. 22). The best character appears to be the clasp viewed from above, when the posterior extremity is seen to be somewhat dilated and bulbous. The penis (fig. 23) is slightly more slender than in the related species. The female genitalia (fig. 24) show a wide bare segment. In two specimens examined the antrum is small, the bacilli rather indefinite.

The early stages are well known, but there does not appear to be any figure showing the sculpture of the egg. The larva is bright yellow, with longitudinal and transverse black lines. A description of the larva of the alpine form *alpicola* Galv. is given below.

Distribution and variation. The distribution of the whole species may be considered here. As in so many European butterflies, eastern and western forms can be distinguished. The very obvious distinctive characters were first clearly defined by Galvagni (1918, *Jber. Wien. ent. Verein* **28** : 128). The typical eastern form described above occurs in Bavaria and in Austria east of the Hohern Tauern. It may occur at low levels. Galvagni reports it from the Otter at 1200–1300 m. I have taken specimens in Styria at little over 3000 ft. altitude. These examples are large and luxuriant, rare in English collections. With these should be associated examples from the Balkans, described below as *leonhardi* Fruhstorfer, although it is doubtful whether any distinction should be made. In the central and western Alps the species occurs commonly in a smaller form named *alpicola* by Galvagni, found only above the tree line and much commoner in collections. In this the colours on the upper surface are usually somewhat faded in both sexes when compared with typical *cynthia.* In the extreme west, in the Alps of Provence and Piedmont, *alpicola* is further modified to *spuleri* Rober, in which the red macules are often partly obliterated and the ground-colour is paler below. All these forms are connected by intermediate specimens which appear between the areas in which the principal modifications are found in their maximum development. In other respects the species is relatively constant and marked aberrations are rare. Some female examples show a more variegated facies due to the presence of pale yellowish or white macules external to the median fascia of the fore-wing (*variegata* Turati and Verity).

Localities :—LOWER AUSTRIA : Otterberge ; Schneeberg ; Raxalpe ; Traunstein bei Gmunden (Schawerda) ; Salzkammergut (Kolisko) ; Zirbitzkogel (Preissecker). STYRIA : Leopoldsteiner See bei Reichenstein (L.G.H.). BAVARIA : Rotwand (L.G.H.) ; Osthelder gives many localities and altitudes from 600 m. upwards. There are no reliable records from the Carpathians, the Siebenburge or from Krain.

Euphydryas cynthia mod. ***leonhardi*** Fruhstorfer.

M. cynthia leonhardi Fruhstorfer, 1916 (1917), *Arch. Naturg.* **82** (A) (2) : 5. Loc. Bulgaria Rhodope Mountains.

M. cynthia drenowskii Rober, 1926, *Ent. Mitt.* **15** : 227. Loc. Macedonia—Pirin Mountains.

Smaller than the larger specimens of typical *cynthia.* In the male the black shading at the wing-bases is little developed, and the white ground-colour appears to be more prominent. The usual red macules are well developed. The female is not remarkable, but paler than specimens from Styria and closer to the Swiss form on this account. Variegation of colour sometimes appears on the upper surface of the female.

This form appears to me to be indistinguishable from specimens I have from Bavaria. As my series is not extensive I have retained the name until more material is available for comparison. I have seen no specimens from the Pirin Mountains, but it is probable that they are similar to those from the Rilo, and I have therefore grouped them together. *E. leonhardi* is to be regarded as a race showing modification by alpine conditions less marked than in specimens from Western Europe and the High Alps.

Localities :—BULGARIA : Rilo Dagh, 8000 ft., July (Elwes) ; Popova, Schapka Pass ; Eleni Vrh., 2300 m. (Rebel). MACEDONIA : Pirin Mountains (Rober).

Euphydryas cynthia mod. *alpicola* Galvagni.

M. cynthia alpicola Galvagni, 1918, *Jber. Wien ent. Ver.* **28** : 134. Loc. Brenner (Austria).

Fore-wing ♂ 18–20 mm., ♀ 22–25 mm.

This is decidedly smaller than the eastern form. In the male the colouring is less bright. The black markings are often diffuse, and may encroach upon the submarginal macules and marginal lunules. On the under surface the markings of the hind-wings are less bold than in the typical form. In the female, too, the ground-colour is less intense and the black markings are finer.

This high-mountain modification is found in the Alps from the Hohen Tauern westwards (Galvagni), including the Tirol and Salzburger Alps, the Dolomites and Switzerland. In the extreme south-west, in the Alps of Piedmont and Provence, this form is further modified. On the upper surface of the males the black pattern is more extensive but not intense, with the red macules on the fore-wings often entirely obliterated. On the under surface both sexes are paler than usual. The change of tone is particularly noticeable on the hind-wings. Very marked examples of this modification from the Val Pesio, in the Ligurian Appenines, have been named *spuleri* by Rober, often associated with the female modification *variegata* Turati and Verity. The species does not pass west of the Rhone valley, and it is absent from the Pyrenees. The butterflies rarely appear below 6000 ft., and in suitable localities they fly in great numbers. They love to lie with outstretched wings sunning themselves upon low Juniper bushes. I have found the larvae abundant towards the end of June at Breuil, in the Val d'Aosta, at 7000 ft. Most were then in the last instar, and all were feeding upon *Plantago alpina*. The full-grown larva is about 3 cm. long, the head, eyes and legs black. Each segment shows a large black dorsal patch which extends down to the spiracular line, while the intersegmental crease and a spot behind each dorsal spine is bright buttercup yellow. Another yellow spot is placed on each side of the posterior inferior angle of each dorsal shield, and below the spiracles there are irregular yellow marks which extend down the posterior aspect of each proleg. The long spines are black, the dorsal series absent from the three thoracic segments, and yellow markings extend anteriorly in their place.

Localities :—AUSTRIA : Tirol ; Salzkammergut, Gross-Glockner district, Molltaler Alps. ITALY : Dolomites. SWITZERLAND : Appears on all suitable mountains. FRANCE : Alps of Savoy and Provence, and on the neighbouring mountains of Italian Liguria.

The following is a list of named subspecies, modifications and aberrations of *Euphydryas cynthia* :—

alpicola *M. cynthia alpicola* Galvagni, 1918, *Jber. Wien. ent. Ver.* **28** : 134. Loc. Brenner. The small mountain form of the western Alps.

aurinoides *M. cynthia* ab. *aurinoides* Kiefer, 1918, *Z. Ost. ent. Ver.* **3** : 108. Loc. Rottenmanner Tauern. A ♂ form with the macules of the submarginal band continuous.

brunneomarginata *M. cynthia* ab. *brunneomarginata* Kiefer, 1912, *Ent. Rundsch.* **29** : 70. Loc. Matteriegel. The black markings are extensive and the marginal spots brown.

drenowskii *M. cynthia drenowskii* Rober, 1926, *Ent. Mitt.* **15** : 227. Loc. Macedonia. A brightly marked race from the Pirin Mountains. See p. 454.

fasciata *M. cynthia* ♀ form *fasciata* Wehrli, 1920, *Mitt. ent. Ver. Basel* : 2.

Loc. Switzerland (fig.). Loc. Simplon, Fusio. On upper side black markings are extensive as in the male.

impunctata *M. cynthia* ab. *impunctata* Hoffman, 1911, *Int. Ent. Z.* **5** : 227. Loc. Zirbitzkogel. Without pupils in the submarginal fascia of the hind-wings.

leonhardi *M. cynthia leonhardi* Fruhstorfer, 1917, *Arch. Naturg.* **82** (A) (2) : 5. Loc. Bulgaria. A brightly marked race near the typical form. See p. 454.

leucophryne *M. cynthia* ab. *leucophryne* Ochsenheimer, 1816, *Schmett. Europ.* **4** : 103. Loc. North Tirol (?). = Hb. 608/9. The white marginal spots are prominent on both wings.

mundata *M. cynthia* form *mundata* Turati & Verity, 1910, *Bull. Soc. ent. Ital.* **42** : 206. Loc. Valdieri. The black discal stripe of the fore-wings absent. This seems to be a common form in the west.

obscurior *M. cynthia* ab. *obscurior* Hofer, 1920, *Soc. Ent.* **35** : 46. Loc. Oetscher district. A small dusky female.

pallida *M. cynthia* ab. *pallida* Spuler, 1908, *Schmett. Europ.* : 21. Loc. Piedmont (nec. *M. cinxia* ab. *pallida* Tutt, 1896). Male form in which the red macules are suppressed. See *spuleri* Rober.

privata *M. cynthia* form *privata* Stauder, 1922, *Ent. Anz.* **3** : 30. Loc. Salzkammergut. A female form with distorted pattern.

reducta *M. cynthia* form *reducta* Vorbrodt, 1911, *Schmett. Schweiz.* **1** : 47. Loc. Switzerland. The dark median fascia on the fore-wing is strongly reduced. Appears to correspond with *mundata* Turati & Verity.

spuleri *M. cynthia* subsp. *spuleri* Rober, 1926, *Ent. Mitt.* **15** : 226. Nomen. nov. pro *pallida* Spuler, 1908, nec, Tutt, 1896. See p. 454.

tricolor *M. cynthia* ab. *tricolor* Schawerda, 1926, *Verh. zool.-bot. Ges. Wien* **67** : 74/75. Loc. North Tirol. A variegated female form. Corresponds with *variegata* Turati & Verity.

umbrata *M. cynthia* form *umbrata* Galvagni, 1918, *Jber. Wien. ent. Ver.* **18** : 136. Loc. Finstertalsee. Melanic form with markings on fore-wing nearly obliterated. H.-S. fig. 666/667 specified as typical.

variegata *M. cynthia* form *variegata* Turati & Verity, 1910, *Bull. Soc. ent. Ital.* **42** : 205. Variegated female with pale macules on the fore-wing. Name is preocc. by *M. asteroida variegata* Stgr., 1901. See *tricolor* Schawerda.

EUPHYDRYAS AURINIA Rottemburg. Distribution Map 6.

Papilio aurinia von Rottemburg, 1775, *Naturforscher* **6** : 5. Loc. Paris.
Papilio lye Bergstrasser, 1780, *Nomencl. Ins.* **4** : 28. Loc. Hanau, Germany.
Papilio koloswarensis Piller and Mitterpacher, 1783, *Iter.* : 41. Loc. Slovania.
Papilio matutina Thunberg, 1791, *Insecta Suecica* **2** : 31. Loc. Sweden.

Fore-wing ♂ 17–19 mm., ♀ 18–22 mm.

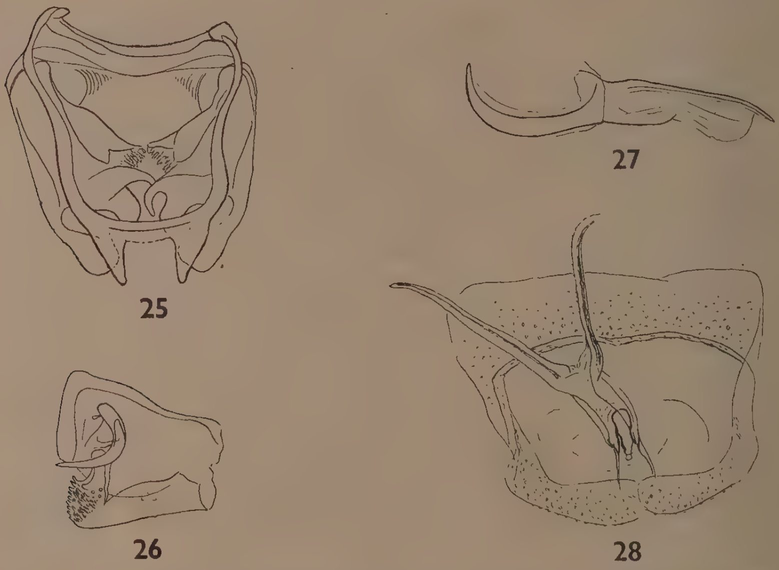
This insect is so well known that an extensive description is unnecessary. On the upper surface the usual pattern is outlined with black. The cellular macules of the fore-wing and the submarginal fascia are orange-red, the latter not rarely showing a yellow pupil in each macule. On the hind-wing the basal and submarginal fasciae are also orange-red, the latter sometimes very wide and showing a small black point in each macule. Elsewhere the ground-colour is typically yellow, the post-discal macules often making a conspicuous series across both wings. The rather wide black border along the outer margin is formed of double fine black marginal lines with a dusky space between them. On the under surface the black markings scarcely appear on the fore-wing, except in the cell. The hind-wing is yellowish, with orange-red macules and fasciae. Each small submarginal black dot is placed in a yellow spot. The female is a good deal larger than the male, but is not otherwise different.

The male genitalia (fig. 25) have a short ringwall. The tegumen is scarcely developed, but on each side is a large and wide subuncal or scaphial element which tapers rapidly to a point. Each process is supported below from the vinculum by a fold which shows a sculpture of minute pits. The clasp (fig. 26) is almost quadrilateral, and the lower and posterior angle bears an elaborate set of long teeth. The narrow sickle-shaped harpe extends backwards and medially to meet its fellow on the opposite side. The short superior limb is finely granular. The penis (fig. 27) is less curved than it is in the *maturna* group. Viewed from above, *the female genitalia* (fig. 28) show a wide scutum which is almost quadrilateral, with a shallow depression on each side of the ostium. It is bounded by closely tuberculated rolled margins, well-developed distally. The long divergent bacilli show a few small spines along the inner margins. They are joined to form a stem or antrum which is grooved into a channel supporting the bursal duct as it descends to the ostium, which opens directly externally. The bursa itself has not been demonstrated.

Biological features and early stages. The egg is of the usual Euphydryad shape, pyriform and flat on the top, the upper half showing 18 to 20 ribs. In colour it is pale shining brown. The eggs are laid in large masses of 100 or more. The larva, when full grown, is black with rather short black spines (fig. 5, p. 441) arranged in nine rows from the 4th segment. The 1st segment shows only hairs, the 2nd and 3rd have two spines each. The dorsum and sides show large numbers of minute white dots which are especially numerous to form a rather vague white stripe down the centre of the back. The head and legs are black, the claspers and under parts brownish. The pupa is cream-coloured, marked with black and orange, and suspended from a leaf or twig enclosed by a fragile tent of leaves. The larvae hatch at the end of June or July (in England), and live in a common web as a large family until the end of August. They have then reached the second instar, and hibernate in their web until March, when they leave the web and feed singly until full grown at the end of April. At this time they are easy to find and to rear, but many are killed by parasites, especially *Apanteles bignelli* and *spurius*. In northern Europe the usual food-plant is Scabious, and especially *S. succisa*, but *Digitalis*, *Plantago*, *Veronica*, *Geranium* and *Lonicera* are all recorded, while in Switzerland Vorbrodt says that after hibernation Gentian species are preferred. The low webs of the young larvae are often in moist meadows which may be flooded in winter, and it has been suggested that the larvae are able to live for long periods under water during the hibernating phase. In England it has been noted that the species inhabits two distinct biotypes. Colonies appear in wet marshy meadows, and also not uncommonly upon dry banks of the southern chalk hills. This insect is notable for periodic fluctuations in numbers in a given locality. Many observers have reported vast swarms of larvae seen from time to time, and such abundance may be followed by unusual rarity or even by disappearance of the colony. The colonies may show marked genetic instability associated with rapidly increasing populations, abnormal forms become common, and a most remarkable picture is presented. A single colony was kept under observation for 55 years, and many interesting details of behaviour are given by Ford (1930, *Trans. ent. Soc. Lond.* **78** : 345–351).

Distribution. This well-known butterfly presents many features of exceptional interest. The habitat lies roughly between the 40 deg. and the 60 deg.

of north latitude, and extends from the Atlantic to the Pacific coasts. Three definite subspecies can be distinguished, all of which show marked local variation along similar lines, which is due, no doubt, to the effects of climate and other local conditions, to which the species is clearly sensitive. The typical subspecies is a common insect in temperate Europe. From Eire, France and Spain it spreads eastwards across the continent. Through most of its range it is a lowland insect, but in Spain and in northern Africa it ascends to sub-alpine levels at 5000 ft. or more. In these countries it appears in a slightly modified form, and reaches the southern limit of its distribution. It scarcely enters peninsular Italy and is altogether absent from Greece, but it occurs again in Asia Minor and in northern Persia. There is every reason to think that the insect flies throughout European Russia and western Siberia; it is well known in the Altai Mountains, and extends north of these to the Vitim and Vilui Rivers.



Figs. 25–28.—*Euphydryas aurinia* Rott. 25. Male genitalia, dorsal view; 26. Clasp, medial view; 27. Adeagus; 28. Female genitalia.

E. aurinia siberica Staudinger is the true oriental subspecies which appears east of Lake Baical and extends through the Amur basin and Mongolia to the Ussuri and Korea. This large form, which shows slight but unmistakable characters in the wing-pattern, appears with little modification on the plains and in the mountains up to 8000 ft. altitude. Wing-markings in the aurinia group are so stable that the differences which appear between *aurinia* and *siberica* might easily suggest a specific distinction. An examination of the genitalia does not support this view, although minor differences can be found.

The third subspecies, which is dealt with as *E. aurinia debilis* Oberthur, is an Alpine form which flies above the tree-line in the Alps of central Europe and the Eastern Pyrenees. The specimens are small, and the colour variable, but as a rule they can be distinguished without difficulty from typical *aurinia*. Both forms occur in many districts, but then the flight-places of *debilis* are separated by 2000 ft. to 3000 ft. of altitude from the haunts of the lowland *aurinia*, and there can be no doubt that the biological characters of the two insects are entirely distinct. It is reasonable, therefore, to regard the two forms as distinct species, as has been suggested by many authors, *e.g.* de Prunner, Treitschke (1834, *Schmett. Europa* **10** : 4) and Villiers & Guénée (1835, *Tables Synopt.* : 133) and others in recent years. On the other hand, I have not been able to discover any morphological feature which enables a definite division to be made, and the distinctions of wing-marking are of a kind that might well be due to ecological factors. Another alpine form, *banghaasi* Seitz, appears in eastern Siberia, in the Sajan and Kentei Mountains, where it flies at about 6000 ft., while the lowland *aurinia laeta* Christoph occurs in the neighbouring valleys. It is likely that the relationship that exists between *laeta* and *banghaasi* is similar to that of *aurinia* and *debilis*. It would be logical to separate *debilis* and *banghaasi* from *aurinia* upon biological grounds, and, in view of their resemblance, to unite them as a single Alpine species. I should certainly do this if I could find the smallest morphological feature to allow of precise distinction between the two species, but this has not been possible. Without such a distinction other difficulties present themselves, and it is hard to say whether *banghaasi* should be treated as a distinct species, or as *aurinia*, or as *debilis*. The form *pellucida* Christoph from the Caucasus presents a similar problem. I feel therefore that it is not practicable to suggest specific distinctions in the absence of any reliable feature for specific identification. It is easier to consider *aurinia* as a supra-species with the European Alpine forms grouped together under the general subspecific heading of *debilis* Oberthur, while *banghaasi* Staudinger is treated as a second Alpine subspecies. At the same time, I must point out that the existence in the same district of two subspecies occupying different habitats is certainly unique among Melitaeid butterflies, and there can be no doubt that the lowland and Alpine forms of *aurinia* have a very unusual relationship one with the other. There is a full discussion on biological differentiation of this kind by Julian Huxley (1942, *Evolution* : 295).

Euphydryas aurinia aurinia Rottemburg loc. cit.

This name was applied by von Rottemburg to "Variety D" of *Le Damier*, described by Geoffroy (1762, *Histoire des Insectes* : 45). The outstanding character of the typical form of this butterfly is expressed in Geoffroy's descriptive words—"*alis fulvis . . . utrinque . . . fasciis tribus flavis.*" Such specimens are very generally distributed with little material variation from southern England and northern France across Germany, northern Switzerland and Austria to central and southern Russia. In specifying this as the typical form, Seitz (1909, *Grossschm. Erde* **1** : 214) points out that there is marked colour contrast and well-developed black pattern. This common form occupies a position midway between the extremes of a well-marked cline which is recognisable throughout most of the distribution area of the subspecies, and modification appears as the northern and southern limits are approached. On the one hand there occur specimens in which the yellow macules are less obvious, or are replaced altogether by the tawny ground-colour, when there is little or no colour contrast on the upper surface. Such examples may be referred to *artemis* Schiffermuller (1775, *Syst. Verz.*: 332), and they have been named again as aberrational forms, *e.g. brunnea* Tutt, *ochrea* Tutt. They appear more commonly in central France and southern Germany and lead to the modification *provincialis* Boisduval, in which the contrast of red, yellow and brown disappears on the upper surface, and the wings are nearly, or quite, unicolorous buff. This modification, described below, replaces the typical form in many southern localities, for example in southern France and Dalmatia, while it occurs also quite commonly in Asiatic Turkey. In such specimens the black markings on the upper surface are fine and delicate. At the other end of the series are races in which the colour contrast is exaggerated, with the yellow macules pale, sometimes nearly white, the submarginal fasciae deep orange red, and with heavy black markings. These specimens are referable to *hibernica* Birchall, a name which has 20 years' priority over *praeclara* of Kane, which is so often used for this form. It appears to be racial in many parts of Eire, and similar races have been described from Scotland (*scotica* Robson), especially from the west coast and Hebrides Islands (Heslop Harrison, 1943, *Ent. Rec.* **27**: 55). Dark and brightly-variegated forms are also recorded from northern England and Wales (*acedia* Fruhstorfer). These two names refer to transitional and slightly less melanic forms, and I have not seen any series from Scotland in which the colour contrast is so marked as in some races of *hibernica*, *e.g.* from Co. Kildare. Still less melanic, and with diminished colour contrast, are specimens from southern England (*anglicana* Fruhstorfer) which certainly come very close to the typical form as it flies near Paris. Fruhstorfer also points out the marked similarity between specimens from southern England and examples from sub-Alpine levels in Bulgaria (*bulgarica* Fruhstorfer) and Bosnia (*balcanica* Schaw.), which probably means that the species lives under similar ecological conditions in all these localities. In southern Italy, in the province of Caserta, several colonies of *aurinia* are known. The insect flies here at 5000 ft., and the form is nearly typical with some tendency to *brunnea* Tutt and to *provincialis* Boisduval, but many examples show quite normal colour contrast (*aurunca* Turati). Pronounced colour contrast may appear without emphasis of the black pattern in a form described below as *sareptensis* Staudinger, and commonly found in Asia Minor associated with the *provincialis* series. It is apparent that the melanic *hibernica* modifications appear in cold and wet localities, while the *provincialis* forms develop in the south of the distribution area where conditions are warm and dry. This is strongly suggestive of climatic influence, and there is little evidence of true geographical or subspecific variation in the series. Such forms are best classed as *formae tempestatis*. An unexpected modification appears in Spain, Portugal and northern Africa. The butterfly attains a large size, with a deep orange-red ground-colour on the upper surface, which often invades the usual yellow macules. This form is described below as *beckeri* Lederer and it is developed from *provincialis*, with which it is connected by transitional races such as *castillana* Oberthur, while the heavy black pattern so common in mountain forms is seen in *kricheldorffi*

Collier from high levels in the Asturias. This series is peculiar to Spain, Portugal and Morocco, and although the characteristic features are not well developed everywhere nor in all specimens, it may represent a partially-developed subspecies.

Localities :—ENGLAND and WALES : very local but not uncommon in some districts, especially in the south. SCOTLAND : locally as far north as the Caledonian Canal, also in the Hebrides, reported from Gunna, Jura, Tiree, Rhum and Islay. IRELAND : generally common and widely distributed, usually in the dark form *hibernica* Birchall. FRANCE : common and generally distributed in the lowlands; in the Pyrenees flies up to 5000 ft. ITALY : a few colonies only, modified towards *provincialis* Boisd.—Caserta, Monte Petrella, 5000 ft., 25 May ; Polleca, 700 m., 21 May ; Iraine, 70 m. ; also in the north from Monte Generoso (*comacina* Turati) ; Tessin, Monte Lema (*volupis* Fruhst.). SPAIN and PORTUGAL : widely distributed in the form *beckeri* Lederer or transitional specimens, Barcelona, Guadarrama, Granada, Asturias Mts., etc. GERMANY, AUSTRIA, HUNGARY, BOSNIA, DALMATIA, GALICIA : widely distributed. SWITZERLAND : occurs in the valleys, but is absent from the mountains except in the form *debilis* Oberthur. POLAND, ESTLAND, CURLAND, LIVLAND : widely distributed. NORWAY, SWEDEN, FINLAND : rare and local in the south of these countries. RUSSIA : reported by Erschoff & Feld to extend across central and southern Russia. I have no recent records and I have seen no specimens except from Sarepta. TURKEY IN ASIA : well known from Amasia and other localities in the north in the form *provincialis* Boisd. or *sareptensis* Stgr. NORTHERN AFRICA : a few colonies known from Morocco in the form *beckeri* Led.

The following modifications grouped under the names *provincialis* Boisduval and *sareptensis* Staudinger, with *comacina* Turati, appear in the warm and dry areas of southern Europe and Asia Minor. All these forms are characterised by the finely-drawn black pattern and the pale tone of the ground-colour of the upper surface. Although at first sight the distribution suggests a geographical race, it is probable that the differentiation depends entirely upon ecological factors. Within this distribution area more typical forms appear when the species occurs under cooler conditions in mountains at a considerable altitude. Thus, while *provincialis* is met with on the plains of northern Italy, it is already less modified at 1000 m. above Novaggio, where it flies in June, and at 5000 ft. in the mountains of southern Italy the species appears in a form close to specimens from Bavaria. In the Balkans there appear similar changes, and the mountain forms are scarcely distinct from those of north-western Europe. Such instability is obviously closely related to environment, but otherwise is without geographical significance.

Euphydryas aurinia mod. ***provincialis*** Boisduval.

M. aurinia var. *provincialis* Boisduval, 1828, *Index Methodicus* : 17. Loc. Provence—France.

Fore-wing ♂ 19–22 mm., ♀ 20–25 mm.

This is usually slightly larger than the typical form. On the upper surface the black pattern is even and delicate. The ground-colour is pale reddish-brown, but this varies a good deal in different colonies. On the upper and under surfaces there is little colour contrast, and the markings are pale with a characteristic sandy tone. The female is often a good deal larger than the male.

Distribution and variation. Most typical examples of this form appear in Provence, in the Departments of Var and the Alpes Maritimes. It is developed only in warm districts, and in central France it merges with the typical form which is found, for instance, in the Mont d'Or. Quite characteristic *provincialis* also appear in Asia Minor, associated with the more variegated *sareptensis* Staudinger. A closely similar form, in which the ground-colour is less brilliant, has been taken at low elevations in a few localities in Piedmont. These transitional specimens have been named *moritura* by Verity (1928, *Ent. Rec.* **40** : 89) ; they appear also in southern France and in Serbia. The distinction from *provincialis* is very slight, and no doubt in many places no real distinction can be made. The large *aurinia* from the lowlands of Dalmatia are similar to typical French specimens of *provincialis*, but often the black pattern on the upper surface is even more delicate, the wings look wider, and on the under surface the hind-wings are more brightly marked. This minor form has been separated by Rober as *rotunda* (1926, *Ent. Mitt.* **15** : 228), and referred in error to *desfontainii* Godt., a species which does not occur in the Balkans. The females of *rotunda* are particularly impressive and large. In mountainous districts the specimens usually approach the typical form (Rebel, 1904, *Ann. naturh. Hofmus. Wien* **19** : 155). (See p. 460.)

Localities :—FRANCE : principally in the Alpes Maritimes and Var, but individual specimens may be found over a wider area ; La Turbie (June), Col de Brons (June), Menton at 1000 ft., 15 May, Draguignan, very fine (Haig-Thomas), La Farlede, Digne, Hyères, Mont Pacagnalia, Pegomas, etc. ITALY : once known from a few localities near Turin, but scarcely seen in recent years. Other Italian colonies of *aurinia* show entirely different forms. DALMATIA, BOSNIA, ASIA MINOR : Broussa, Amasia, the prevailing form on the plains, and often accompanied by examples transitional to *sareptensis* Staudinger.

Euphydryas aurinia mod. ***sareptensis*** Staudinger.

M. aurinia var. *sareptensis* Staudinger, 1879, *Hor. Soc. ent. Ross.* 14 : 265. Loc. Sarepta.

Fore-wing ♂ 19–20 mm., ♀ 21–24 mm.

In characteristic examples of this handsome form the fore-wings appear somewhat elongated and narrow. On the upper surface the black markings are not heavy, and in this respect there is marked approach to *provincialis*. The most striking character is the very brilliant colour contrast. The ground-colour is pale yellow or nearly white, and the reddish macules and submarginal fasciae stand out in sharp contrast. Pale macules appear in the submarginal fascia of the fore-wing. On the under surface of the fore-wings the yellow markings are extended, and little of the orange ground-colour is to be seen. On the hind-wings the orange fasciae are light, more or less diluted by the greyish-yellow ground-colour.

This form occurs from southern Russia and Asia Minor to the Ural Mountains, although not every example from this district is well marked. It flies with *provincialis*, but shows colour contrast of the *hibernica* type, and represents a well-marked cline, of which both extremes and intermediates may be found in some districts, notably Amasia. According to Staudinger (*loc. cit.*) the unicolorous forms appear more commonly in certain years. He states that at Amasia he found examples not separable from German *aurinia* flying with highly-coloured oriental forms. Specimens in which the ground-colour is yellowish instead of nearly white, with the colouring less vivid, may be referred to *amasina* Seitz. This less extreme form is certainly commoner in Asia Minor and at Sarepta, judging by my series. In some examples the under surface of the hind-wings is very grey and the orange fasciae scarcely developed. This unusual feature is present in specimens from the Ural Mountains, and I have it rather less well marked from Sarepta. The fully-developed *sareptensis* modification is truly comparable to *phoebe ornata* Christoph and to *maturna uralensis* Staudinger, all of which show specially brilliant colour contrast on the upper surface, and which occur in the same district, at least in the Ural Mountains. It is possible that the factor responsible for the brilliant colour may operate in this district upon all three species. A strong tendency towards extreme colour contrast is said to appear also in specimens of *aurinia* taken at about 3000 ft. on Monte Lema, north of Lugano, and named *volupis* by Fruhstorfer. I have not seen specimens of this form, but if there is truly a development of *sareptensis* characters this is the only locality in Europe where such forms are known to appear.

Localities :—Asia Minor : Amasia. Many specimens, but poor data. Malatia. Southern Russia : Sarepta (type), many specimens, but no good data. Ural Mountains. Kizil-skaja. Italy ? : Monte Lema, near Novaggio, 8 June 1917, 1000 m. (*volupis* Fruhstorfer).

Euphydryas aurinia mod. **comacina** Turati.

Mel. aurinia comacina Turati, 1910, *Ent. Z. Stuttgart* **23** : 223. Loc. Monte Generoso (Lugano).

Fore-wing ♂ 16–19 mm., ♀ 19–22 mm.

In the male, on the upper surface, the ground-colour is bright tawny-orange, almost or quite unicolorous. On the fore-wing the markings are fine but distinct. The discal and post-discal transverse lines are often close together and a little accentuated, so that the orange submarginal fascia is wider than usual. On the hind-wings the submarginal fascia is also wide, with the black proximal border more or less obsolete anteriorly. On the under surface the ground-colour of the hind-wings is yellowish-buff, with the pattern scarcely indicated in brownish, but the submarginal spots of the hind-wings darker and often large. The female is usually larger than the male, but the markings are similar.

This form is clearly derived from *provincialis* Boisduval. The upper surface alone might be placed as *brunnea* Tutt, and I have specimens from Germany, Austria and southern and central France which are scarcely distinguishable. On the under surface the nearly uniform yellowish tone and obliterated markings produce such a striking and constant facies that a special description is needed. It occurs on dry and stony places, at about 3000 ft., on the hills between the lakes Lugano and Como. I have a short series from the slopes of Monte Generoso, but Signor Luigi Rocca has told me that the species is rapidly disappearing from many localities as more houses are built. About 30 miles north of the habitat of *comacina* there flies another form, *volupis* Fruhstorfer (see p. 479), much closer to *provincialis* and often showing variation towards *sareptensis* Stgr. Further south, in the province of Caserta, a few colonies of *aurinia* are known (see *aurunca* Trti., p. 474). The specimens are close to the typical form, and many examples show normal colour contrast, although *brunnea* forms are common.

Locality :—ITALY : Tessin, Monte Generoso, 1200–1500 m. End of May. Series *ex* Coll. Fruhstorfer, 1919.

Euphydryas aurinia mod. ***beckeri*** Lederer.

M. beckeri Lederer, 1853, *Verh. zool.-bot. Ges. Wien.* **2** : 39. (Abhandlung 5 *Versuch. Eur. Lep.*). Loc. Cadiz.
M. artemis var. *iberica* Oberthur, 1881, *Études d' Ent.* **6** : 54. Loc. Cadiz.

Fore-wing ♂ 19–21 mm., ♀ 22–25 mm.

This is a large and brightly coloured form, and on the upper surface the ground-colour is distinctly reddish. The black markings are heavy, and the marginal lunules of the hind-wing are often obliterated by black. In many specimens the post-discal fascia of both wings is paler, and there may be some yellow macules in the submarginal fascia of the fore-wing, where the proximal marginal line is usually reduced or absent. This unusual feature was noticed by Lederer. On the hind-wing the black marginal dots are often enlarged. On the under surface the fore-wing shows some yellowish macules near the apex, but the black pattern is faintly indicated or absent on the disc. On the hind-wing the ground-colour is pale yellowish-grey, which makes a strong contrast with the orange-red fasciae, which are clearly outlined by black scales, as are the small submarginal dots. The orange submarginal fascia may be conspicuously wide. The female is a magnificent insect, one of the largest Melitaeid forms.

This modification occurs throughout Spain from Catalonia to Andalusia. It is generally supposed that southern specimens are best characterised. Both *beckeri* and *iberica* are names for Herrich-Schaeffer's figures 1 and 2, which came from Cadiz (Herrich-Schaeffer, text **1** : 22). In other parts of Spain, for instance at La Granja and near Madrid, rather smaller examples are common, which may be referred to *castillana* Oberthur. In the Asturias Mountains a still smaller race appears, which flies at 5000 ft. or more, and shows the common characters of a mountain race in heavier black markings and brighter colour contrast. This form has been named *kricheldorffi* by Collier. Various individual variations of this form have received special names, *e.g. morena* Ribbe ; *alfacaria* Ribbe ; *nigrolunulata* Fernandez ; *demaculata* Bubacek, but most of these seem superfluous. The smaller specimens are transitional to forms near *provincialis* Bdv. from southern France, and it should not be difficult to show an unbroken series leading from *provincialis* to fully-developed *beckeri*. It is probable, therefore, that this modification shows the extreme development of a well-marked cline, and the appearance of large *beckeri* in such widely separated localities as Catalonia and Andalusia, with less modified races intervening, suggests that a climatic factor may be partly responsible for the changed characters. A similar or closely allied form was found by Ellison in Morocco. In two specimens received for comparison, the terminal line along the outer margin of the fore-wing is double, and there is no tendency towards black suffusion along the outer margin of the hind-wing. On the under surface the specimens resemble ordinary *beckeri*, and no special name seems to be required.

This form has been bred from the larva many times. The ova hatch in summer, and the young larvae live in nests until late autumn, when they hibernate, probably in the second instar. In March they emerge again, and begin to pupate by the middle of April. Several observers have recorded finding them in the spring, feeding upon a species of *Lonicera* (*cf.* de Worms, 1931, *Entomologist* **64** : 84). Ribbe attempted to rear a large number, which refused all food until he gave them *Lonicera* (*Beitr. Lep. Andal.* : 131). Available records all refer to larvae found after hibernation, and it is not known whether *Lonicera* is ever used by the young larvae.

Localities :—SPAIN : Catalonia, Barcelona etc., Villamajor ; Santa Fe, 1000 ft., May, 3000 ft., July. Asturias, Puerto de Pajares, 5000 ft., June (*kricheldorffi* Col.). Madrid, Guararrama, 2000–4000 ft., May and June (*castillana* Ob.). Andalusia, widely distributed, Granada, May, 5000 ft., Cadiz, Seville, Huelva etc. PORTUGAL : Sierra de Estrela, June, 1000 m. ; Alemtejo, April, 10 m. ; Lagos, May. MOROCCO : Middle Atlas, Immouzer, 17 May, 1937 (*Ellison*). Rif, A'Faska, 10 June, 1 female (*Reisser*).

Euphydryas aurinia mod. ***laeta*** Christoph.

M. aurinia var. *laeta* Christoph, 1893, *Iris* **6** : 86. Loc. Vilui River.

Fore-wing ♂ 18 mm., ♀ 20 mm.

In the Altai and Sajan Mountains *aurinia* is represented by two well-marked forms. In the mountains at high Alpine levels there flies *bang haasi*, a small and dark insect which is described below. At lower levels *aurinia* resembles closely a central European form. The insects are rather small, with heavy black markings on the disc of the fore-wings, but delicate towards the outer margin. There is strong colour contrast between the yellow macules and the reddish orange fasciae. On close inspection these specimens show certain characters which are common in the true oriental subspecies. On the upper surface of the fore-wing there is a single fine terminal line along the outer margin, so that the marginal lunules are wide and deep. On the hind-wing the orange submarginal fascia is wide, and often lacks the usual black border along its inner margin.

I have six examples of this form, and there are seven specimens in the collection at the British Museum. They are all from the area of the Altai and Sajan Mountains, and some are marked with a moderate altitude. This form is probably identical with *laeta* Christoph, of which the typical male and one paratype are in the British Museum. These are, in fact, so worn that the wings are nearly transparent, and it is not possible to make out the true characters, but they agree with my insects in size and general build, and clearly must be closely related. Until there is more material available from N.E. Siberia it is not possible to attempt any close analysis of the forms which occur there.

Localities :—ALTAI MOUNTAINS : Ongodai, H. J. Elwes coll. Tchuja Valley, 2000 ft., H. J. Elwes coll. SAJAN MOUNTAINS : Arasagun-Gol. Three specimens. No further data. VILUI RIVER : typical series of *laeta*. Coll. by Christoph. Typical ♂ in coll. B.M.

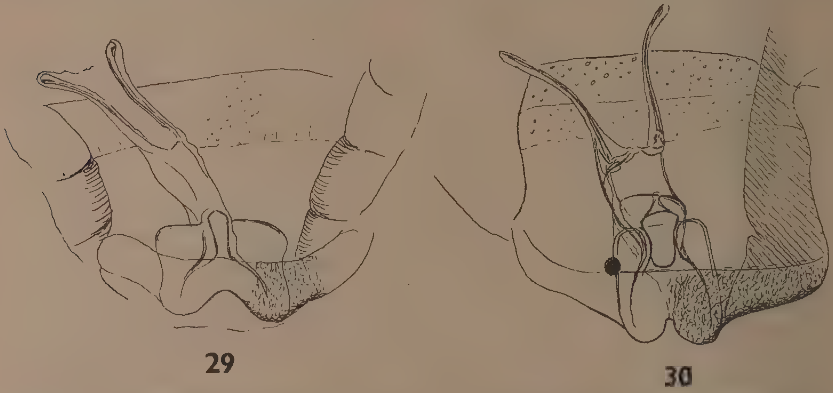
Euphydryas aurinia siberica.

M. artemis var. *siberica* Staudinger, 1861, *Cat.* (Ed. 1) : 7. Loc. Siberia. (Name for *desfontainesii* Fischer de W., *Entom. Imp. Ross.* **5** : 92.)

Fore-wing ♂ 21 mm., ♀ 23 mm.

In the male the fore-wings are pointed and the stalk of nervure 10 is often lengthened. Commonly, the outer margin is flat or slightly concave at nervures 2 and 3. On the upper surface the prevailing tone is orange-yellow. Some very pale macules are often present, particularly in the post-discal area of both wings. On the fore-wings there is a single terminal line, which makes the marginal lunules large. This is a prominent feature in all oriental forms. The usual black markings, excepting the cellular macules, are often rather feeble. On the hind-wings the wide submarginal fascia is conspicuous, and in a typical specimen the black internal border is absent anteriorly. The black points in the submarginal fascia are usually large. On the under surface the black-ringed cellular macules are the most conspicuous marks on the fore-wings, although the yellow pattern is often well developed. The hind-wing shows no unusual feature. In the female the fore-wings are less pointed, but the markings are similar.

The male genitalia in *siberica* resemble those of *aurinia*, but in the female there is a slight difference. The genital plate (figs. 29, 30) is not clearly defined, especially anteriorly, and the auricles are developed as very definite structures on each side of the ostium, while in typical *aurinia* they are less obvious. This distinction holds good for five preparations of *aurinia* from various western localities, and for two preparations of *siberica*. I have no material to show the forms of genitalia and wing marking which may occur in western Siberia, so I have not separated *siberica* specifically, although there is clearly well-marked differentiation from *aurinia* (see fig. 28).



Figs. 29, 30.—*Euphydryas aurinia davidi*. 29. Female genitalia, dorsal view. Loc. Transbaical; 30. Female genitalia, dorsal view. Loc. Khingan Mountains.

This is a true oriental form, which begins to appear east of Lake Baikal. The facies is well characterised, although it is difficult to describe all the distinctive features. The pale colour of typical *siberica* and the fine black markings suggest a "dry" form. The most characteristic examples appear in Mongolia, and I have series from the Changai Mountains and from Troitzkossowsk. Further east, along the Amur, specimens become darker, as the form *davidi* Oberthur, described below. This is really an arbitrary limitation, and leads to a still darker form with heavier black markings and lively colour contrast, called *tenebricosa* by Bang-Haas. This is found typically in the higher mountains of Kansu and the Kuku-Nor, and the colouring strongly suggests modification by a colder climate or higher altitude. This series of forms constitutes a well-marked cline, but the specimens occur in a rather confused distribution, and the characters probably depend more upon local conditions than geographical position. While *davidi* passes into *tenebricosa* towards the south, another modification appears on the lower reaches of the Amur. This is characterised by diminished colour contrast and darker tone with heavier black markings. It is described below as *tjutjujensis*. I have from Charborowka a series of *davidi* already modified in this direction, and the most characteristic examples are from the Tjutjuje district on the Ussuri. The principal clines of *siberica* may be annotated thus :—

. . . *tjutjujensis* . . . Ussuri ; low level.
siberica . . . *davidi* . . .
. . . *tenebricosa* . . . Kansu ; high level.

The material available suggests that the mountain form *banghaasi* in the Sajan and Kentei Mountains is interpolated into the distribution area of *siberica* which occurs north and south of these mountains. In this there is analogy with the western *aurinia* and the Alpine *debilis*. Except in this western area there is no special mountain form of *siberica*. On the contrary, dark but unmistakable *siberica* are found up to 7500 ft. or more in suitable mountains. The total distribution area of the series extends from the Changai Mountains eastwards through Transbaikalia and Mongolia, to the Pacific.

Localities :—TRANSBAIKAL : Changai Mountains, Troizkossowsk, Tchico River, 800 m. ; Seliginsk, 600 m. ; Tchita, June. Also some intermediate or tending to *davidi* Oberthur. Mondy Sajan Mountains, Chulugaischa, 2300 ft., June. Chingan Mountains, Lin-si-hien. NORTH CHINA : Tschili Province, Tunkin-jingze, Hsingan Mountains, 1500 m. ; Chi-feng-hsien.

Euphydryas aurinia siberica mod. ***davidi*** Oberthur.

M. artemis var. *davidi* Oberthur, 1881, *Études d'Ent.* **6** : 52. Loc. North China.
M. aurinia var. *mandschurica* Staudinger, 1892, *Iris* **5** : 323. (Loc. North of Pekin) *Nec M. athalia mandschurica* Fixsen, 1887.

Fore-wing ♂ 23 mm., ♀ 24 mm.

This form is slightly larger than typical *siberica*, and in colouring corresponds to *aurinia artemis*, with the upper surface darker orange-yellow, inconspicuous yellow macules and well-defined black markings. On the under surface also the black markings on the disc of the fore-wings are more complete than is usual in *siberica*. On the hind-wings the orange fasciae are wider, especially in the submarginal fascia, which may be conspicuous. The female resembles the male.

Distribution. I have seen well-marked examples of this modification from the Lower Amur, Manchuria and Korea. More commonly it appears in series from the Amur and northern China, among specimens which are nearer to *siberica*, but the division is rather empirical, and the two forms run into one another.

Localities :—KOREA : Gensan, Poktussan, 2500 m., July, Kjongshong, Shiotsu River, 1500 m. MANCHURIA : Pogranitschnaja (not identified on the map). CHINA : " Pekin."

Euphydryas aurinia siberica mod. ***tenebricosa*** Bang-Haas.

M. aurinia tenebricosa O. Bang-Haas, 1927, *Horae Macrolepidop* : 51. Loc. Richthofen Mts., Kansu, 2500 m., July.
M. aurinia koreana Collier, 1933, *Ent. Rundsch.* **50** : 54. Loc. Korea. *Nec M. aurelia koreana*. Elwes, 1899.
M. aurinia phyllis Hemming, 1941, *Proc. R. ent. Soc. Lond.* (*B*) **10** : 207. Nom. nov. pro *koreana* Collier, 1933, *nec* Elwes, 1899.

Fore-wing ♂ 23 mm., ♀ 24–25 mm.

On the upper surface the black markings are heavy. The post-discal series of both wings and the cellular spot of the fore-wings are almost white, while other macules, including the submarginal fascia of the hind-wings, are orange-yellow, and colour contrast is marked. On the under surface the wings are brightly marked with orange and pale cream, the black markings well developed.

This may be regarded as *davidi* showing modification by cold and damp, and analogous to the *hibernica* form of *aurinia*. The original specimens, or at least two female paratypes, are now in my collection. They are much worn and the colour has faded. I have three other examples also from the Kuku-Nor, clearly of the same form, and intermediate specimens are not rare among *davidi*. This may be looked upon as the extreme melanic form of the cline *siberica . . . davidi . . . tenebricosa*. It is interesting to notice that the features of *siberica* as a subspecies are maintained throughout the series. On the other hand, the local modifications follow the lines already noticed in the typical subspecies in passing from *hibernica* to *provincialis*.

Localities :—Kansu : Richthofen Mts., Liang-tschou, 2500 m., Kuku-Nor : Alt-Tau, 2500 m. Intermediate also from the Amur, Blagowetschensk.

Euphydryas aurinia siberica mod. ***tjutjujensis*** Staudinger i.l.

Fore-wing ♂ 18 mm., ♀ 18–22 mm.

On the upper surface the black pattern is very heavy. On the hind-wing the basal area may be entirely black, and the marginal lunules are filled with black and fused with the outer marginal border, which therefore appears very wide. Along the outer margin of the fore-wing the proximal marginal line remains vestigial or is altogether absent. On the under surface the fore-wings show little marking except the black-ringed cellular macules. On the hind-wing the orange fasciae are wide, especially the basal fascia, which may fill the proximal half of the wing, showing only two or three small circles of paler ground-colour. The female resembles the male, but may be larger.

Distribution. I have seen this form only from the Sichota Alin district, along the coast between the Amur and the Ussuri Rivers. It is developed from *davidi*, and I have seen intermediate specimens from the lower Amur and Ussuri. It is not possible, on account of the peculiar markings, to include *tjutjujensis* in the cline *siberica . . . tenebricosa*. Rather, it appears to represent a different phase of modification, arising in *davidi* and extending in a different direction. The reason for this change is not obvious.

The holotype ♂, allotype ♀ and four paratypes, one ♂ and three ♀, are in my collection.

Localities :—Ussuri : Tjutjuje, Sichota Alin district ; Transitional also from Anutschino, Charborowsk, Sutschanski-Rudnik, Vladivostok.

The Alpine forms of *aurinia* are now described, and these are of exceptional interest. The European series is dealt with under the subspecific name of *debilis*. These butterflies are found in the Alpine zone, above the tree-line, at 5000–6000 ft. and upwards. On the other hand, the typical *aurinia* occurs in central Europe from sea level up to around 2000 ft., so that there is a break of 2000–3000 ft. between the distribution zones of the two. In some localities I have found, upon the same day, *aurinia* at the foot of a mountain while *debilis* forms are flying near the summit. In the Pyrenees typical *aurinia* ascends as high as 5000 ft., but this is below the tree-line in these mountains, and *debilis* appears at 7500 ft. With *debilis* I have associated the eastern *bang haasi* as a separate subspecies. The life history of this insect is not known, but it is certainly an Alpine form, and from this fact, and from its small size and general appearance, it seems to fall into place naturally beside *debilis*, although the differences are too great to allow the two forms to be united. With these I have included the small *pellucida* Christoph from the Caucasus. This form also is known to occur at an altitude of 8000–9000 ft., and its small size suggests an Alpine insect. Few specimens are available for comparison, and nothing is known of its habits and life history. In the absence of biological knowledge concerning *bang haasi* and *pellucida*, it is not possible to assess their taxonomic status with any confidence. The unusual relationship between *debilis* and typical *aurinia* has been discussed on p. 459.

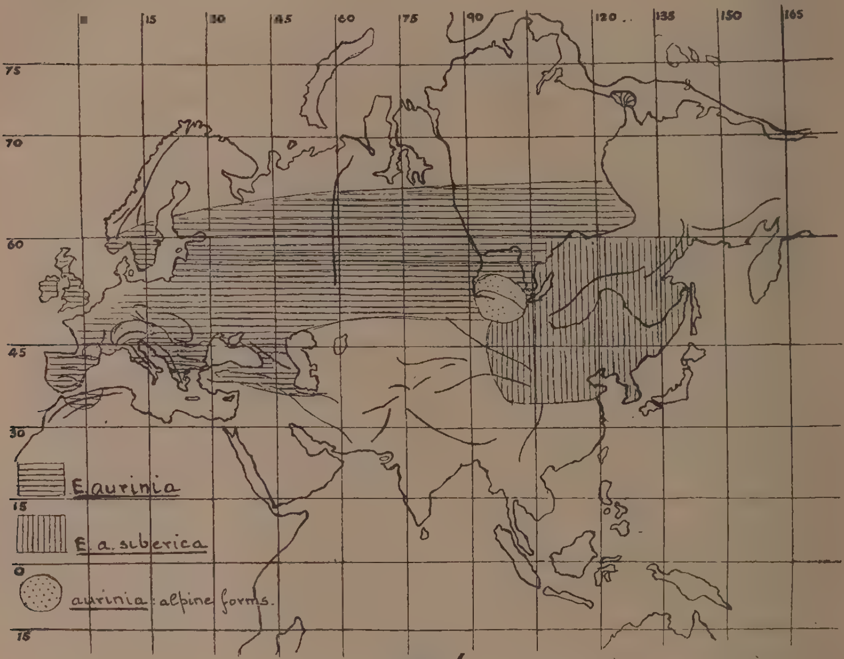
For several generations the Alpine forms of *aurinia* have been known under the comprehensive name of *merope* de Prunner, 1798. This is a primary homonym of *Pap. merope* Fabricius, 1775, and it is unfortunately necessary to discard this well-known name, which must be replaced by *debilis* Oberthur, 1909, and the southern form from the Pyrenees becomes typical of the subspecies. It is at once the smallest and the most brightly coloured of the Alpine forms. The application of the name *debilis* Ob. is somewhat confused by Verity's action, suggesting that Oberthur gave this name to a form from Rennes (1928, *Ent. Rec.* **40** : 89). In retaining *debilis* for the Alpine insect of the Pyrenees it is clear that Oberthur's intention is confirmed, and I feel that Verity's restriction cannot be accepted. These are the relative quotations from the *Études de Lépidoptérologie Comparée* **3** : 226 : "Il-y-a deux races de *Merope* distinctes l'un et l'autre ; (1) la race alpine suisse, à laquelle le nom de *Merope* doit être attribué. . . . (2) la race pyrénéenne et la race alpine française, d'un aspect beaucoup plus rougeâtre que la race alpine suisse, et semblant être une *artemis* bretonne plus petite et un peu étoilée, comme on trouve parfois aux environs de Rennes. . . . La *Merope* des Pyrénées-Orientales, des Basses Alpes et de la Forêt de Rennes est distinguée par moi sous le nom de *debilis*." It will be noted that *debilis* is definitely applied to a form of *merope* de Prunn. Nearly all the *debilis* in the Oberthur collection came from the Pyrenees-Orientales, and it is to these that Oberthur intended the name to apply. Unfortunately no "type" specimen is available, and possibly none was specified. In a later paper (1923, *loc. cit.* **20** : 20) Oberthur states : "Dans les *Études de Lépidoptérologie Comparée*, vol. **3** : 228, j'ai appelé *debilis*, la forme que mon frère et Harold Powell ont prise si abondamment à Pla-Guilhem." In view of the context it is clearly contradicting the author's intention to specify the occasional dwarf specimens from Rennes as *debilis* and to follow Verity in renaming as *pyrenes-debilis* the Alpine form of the Pyrenees. In this connection it is interesting to note that from external characters, and without looking at the locality labels, I am not able to separate from the true high-level *debilis* the five specimens labelled Rennes which are included under the name in Oberthur's collection.

Euphydryas aurinia debilis Oberthur. Distribution Map 6.

M. artemis merope debilis Oberthur, 1909, *Ét. Lép. Comp.* **3** : 228. Loc. Pyrenees Orient. ; Basses Alpes ; Rennes (aberrat.).
M. artemis merope-debilis Oberthur, 1925, *loc. cit.* **23** : 114 (Index).
M. aurinia race *pyrenes-debilis* Verity, 1928, *Ent. Rec.* **40** : 90. Loc. Pyrenees Orient.

Fore-wing ♂ 15 mm., ♀ 17 mm.

On the upper surface this small insect shows a strong resemblance to dwarf *aurinia.* The ground-colour is warm yellow, the black markings firm and complete. On the fore-wing the discal macules and submarginal series are filled with orange-red, the latter containing the usual yellow spots. On the hind-wing the disco-cellular mark and the submarginal fascia often show the same bright reddish colour, but in some specimens the colour contrast is not so marked. The submarginal fascia is formed of a series of round or oval spots, almost discrete, and the fascia is narrower than in typical *aurinia.* The under surface is sandy-yellow, the black pattern of the upper surface reproduced in some shade of orange-brown. On the hind-wings the basal macules and discal markings are faintly outlined with black scales, as are the submarginal dots. In the females, on the upper surface, the colour contrast is less marked, and most examples show the forms *brunnea* Tutt or *ochrea* Tutt. The black markings are well developed. On the under surface the pale colour is noticeable and all markings are indistinct. As a rule the cellular marks of the fore-wings and the basal and discal marks of the hind-wings are thinly bordered with black.



MAP. 6

Map 6.—*E. aurinia.* Distribution, showing principal subspecies.

In series this insect is well characterised, although the distinctive features are not easy to define. Apart from the small size and pale under surface, there is one detail which is worth noticing. On the upper surface of the fore-wings the orange marginal lunules are narrow, and the black edge to their inner border is relatively even, almost a straight line. In *aurinia* the lunules are often much deeper, especially in cellule 3, and the dark inner border is formed of a succession of U-shaped marks.

The genitalia do not appear to differ from those of typical *aurinia.*

Variation. From the characteristic *debilis* of the Pyrenees there is a gradual and progressive modification as the insect is followed towards the north and east. Already in the Dauphine and Piedmont the specimens are usually transitional, of small size, and the colour orange rather than grey. No doubt de Prunner's *merope* belonged to this type, which I have taken above Oulz and also at Breuil. Examples from the Carnic Alps, in the extreme east of the Alpine range, are large and the black pattern is thick, but the ground-colour is distinctly yellow or orange. These specimens came from about 5000 ft., a low altitude, which may account for the large size compared with the western transitional forms, which fly at 7000–8000 ft. These eastern specimens have been identified by Verity as *frigescens* (1928, *Ent. Rec.* **40** : 45), of which the first specimen described came from the Rhone valley. On the under surface of the hind-wing the pattern is relatively distinct, as in many southern specimens which seem to approach typical *aurinia* in this respect. The largest and darkest examples occur in the north, especially in the Allgauer Alps, where the form met with is little, if at all, smaller than the typical *aurinia* which fly on the marshes 3000 ft. below. The common and most widely distributed form of central Switzerland and Austria is slightly smaller but still dark, described below as *glaciegenita* Verity. In general it may be said that the subspecies is largest and darkest in the north and east, and that it becomes smaller and brighter in the south and west. This definite cline of colour change does not appear at all in typical *aurinia*, in which subspecies the cline of variation of size is reversed. In the northern and central Alps *debilis* and *aurinia* cannot be confused, but in the south the brightly-coloured forms of *debilis* are not so easily separable from *aurinia*, and in particular from some forms near *provincialis*, which show little pattern on the under surface of the hind-wings. In fact, some specimens of typical *debilis* from the eastern Pyrenees cannot be distinguished with certainty in the cabinet from dwarf specimens of lowland races of typical *aurinia*, and the two forms are easily confused.

In its habits this butterfly is quite unlike *aurinia*. It usually occurs in large numbers, and flies rapidly over the short Alpine turf. Its movements are so quick that it is often difficult to follow in the bright sunshine.

Localities :—FRANCE : Eastern Pyrenees, Vallée d'Eyne, 17 July ; Cambre d'Aze, 17 July ; Pla Guilhem, 20 July ; Croix de la Roquette, 20 July. ANDORRA : Las Escaldas, 19 July ; En Valira, 19 July ; Esquerdes de Rontja, 28 July.

Euphydryas aurinia debilis mod. ***glaciegenita*** Verity.

Pap. merope de Prunner, 1798, *Lepidoptera Pedemontana* : 73. Loc. Val Variata.
M. aurinia glaciegenita Verity, 1928, *Ent. Rec.* **40** : 43. Loc. Stelvio. Nom. nov. pro *P. merope* de Prunner, 1798, nec *P. merope* Fabr., 1775.

Fore-wing ♂ 16–17 mm., ♀ 17–21 mm.

This is usually a smaller insect than typical *aurinia*. On the upper surface the black-pattern is extended and heavy. In the male the ground-colour is pale yellow or whitish-grey. The reddish-orange cellular and submarginal macules are conspicuous by contrast. The latter are greatly reduced in size by extension of the black pattern, and on the fore-wing may be nearly obliterated. On the hind-wing they remain as a series of round, discrete spots. On the under surface of the fore-wings the pale yellowish macules are well defined upon a reddish-grey ground. On the hind-wings the yellowish markings are obscure, often almost obsolete. The submarginal fascia is faintly reddish, as are the darker macules at the wing-bases, which are commonly outlined with black scales. The female may resemble the male. More often the yellow macules on the upper surface are more or less enlarged.

Occasional specimens show a warmer fulvous tone, and I have one from the Oytal in southern Bavaria which would pass for a southern specimen of *debilis*. Similar specimens are mentioned by Osthelder.

The larva is described by Villiers & Guénée as showing marked differences from that of typical *aurinia* (*Tableaux Synopt.* : 132), and many authors have repeated this statement. This is an error, and the resemblance to typical *aurinia* is very close. I have bred a series from the Matterhorn, and give the following description. The larva described by Villiers & Guénée is that of *E. cynthia.*

The full-grown larva is about 2 cm. long, the head black, and the spines short as in *athalia*. The general coloration is black, with an obscure silvery band down the dorsum and another along the spiracles on each side. The legs and claspers are yellowish-brown. On closer examination the whole body is black, sprinkled with minute white dots, which vary in number in different specimens. In most examples the white atoms are very numerous along the dorsum and spiracles, and so produce a silvery fascia down the back and along the sides. The lateral fascia is intensified by a band of absolutely black skin above the spiracles. The body is pale grey-green beneath. The larvae were numerous in June, at 7000 ft., all feeding upon the flowers of *Gentiana acaulis* and *verna*. Vorbrodt records *Primula viscosa* as a favourite food-plant for *glaciegenita*, but he does not state whether this is used in early or late instars. This larva is not identical with that of lowland *aurinia*, but it is very similar.

Variation. The variation met with in *glaciegenita* is discussed on p. 471.

Localities :—FRANCE : Alps of Savoy and Dauphine, the latter transitional to *debilis*. ITALY : Alps of Piedmont, transitional to *debilis*. Carnic Alps, recorded only from Monte Houbolt, 1850 m., by L. Rocca. SWITZERLAND : on all montains of suitable altitude. In the south many examples are transitional to *debilis*. It appears to be absent from the Bergamasker Alps. GERMANY : local and uncommon in Allgauer Alps, *e.g.* Nebelhorn, 6000 ft., July. Gerstrubener Alpler and Salzburg Alps (Osthelder). AUSTRIA : recorded by Caradja from some of the highest summits. I have seen no specimens from these mountains. Not recorded from the High Tatra.

Euphydryas aurinia pellucida Christoph.

M. aurinia var. *pellucida* Christoph, 1893, *Iris* **6 :** 86. Loc. Eastern Caucasus, Darghestan, Kurusch, and Romanoff, 1897, *Mém. Lépid.* **9 :** 190, fig.

I have seen only one specimen of *aurinia* from the Caucasus which corresponds exactly with Christoph's description. This is a paratype in the collection at the British Museum. In this specimen the wings are much worn and partly transparent, and the pattern is only vaguely indicated. I think there can be no doubt that the description was based upon a series of similar specimens, and consequently the racial characters are difficult to determine. I have two small examples from the Caucasus with pale undersides, unfortunately without exact data, but from the characters present I should think they come from a high altitude. I assume that these do represent Christoph's *pellucida.* Little is known of the distribution of the species in the Caucasus, and further data would be welcome. The following is a short description of my two specimens :—

Fore-wing ♂ 16 mm. No female available.

In this small form the fore-wings are narrow, and the general shape compares best with *debilis* Oberthur. On the upper surface the ground-colour is yellow, and the usual macules and fasciae of deeper orange are present. There is a close resemblance to *debilis,* only the black pattern is not quite so heavy, and the submarginal fascia of the hind-wing is wider and less distinctly separated into macules. On the under surface the yellow markings of the fore-wings are prominent, and exactly resemble *debilis* forms. On the hind-wings the markings are rather faded. It appears to me that this insect should be associated as a mountain form with *debilis* Oberthur, but with so little material for study the correct taxonomic position must remain uncertain. Since *pellucida* was recorded by Christoph, from 8000 ft., the biology probably approaches that of *debilis* rather than that of typical *aurinia.*

Locality :—EASTERN CAUCASUS : Darghestan, 8000 ft. (*Christoph*), paratype in B.M. " Caucasus," no further data. L.G.H. collection (2 ♂♂).

Euphydryas aurinia mod. ***bang haasi*** Seitz.

M. aurinia bang haasi Seitz, 1908, *Macrolep. Erde* 1 : 214. Loc. Kentei Mountains.

Fore-wing ♂ 17–18 mm., ♀ 19 mm.

On the upper surface of this small form the black markings are usually heavy, but on the fore-wing there is a single fine terminal line along the outer margin. The ground-colour is very pale, as a rule, often nearly white, and the usual reddish macules and fasciae are somewhat reduced by the wide black pattern. The under surface is not remarkable.

The genitalia do not differ from those of typical *aurinia.*

The whole facies of this insect is expressive of a mountain form, and full of character. I have had an opportunity of examining the typical specimen of *bang haasi,* in which the ground-colour is a good deal paler than in the specimen illustrated in Seitz, Pl. 65 C, although less pale than in several of my series, which often recall the darker forms of *debilis.* The darker specimens certainly come from high altitudes, and I have several in which the altitude is marked at 5000–6000 ft. The insect seems to be common in the Altai and Sajan Mountains, and probably also in the Kentei range, whence Seitz described it, although I have not seen any specimen from there except the type.

Localities :—ALTAI MOUNTAINS : 5000 ft., H. J. Elwes coll. SAJAN MOUNTAINS : Tunkinsk Weissberge, July, 2000 m., Munko Sardyk : no further data. MALCHAN MOUNTAINS : Borochojewa, 800 m. (requires confirmation). KENTEI MOUNTAINS : no further data (Seitz).

Note. M. aurinia emba Fruhstorfer is described as being very like *bang-haasi.* I have not seen this form (from Uralsk). *M. aurinia* var. *asiatica* Staudinger, described from the Ala Tau, has not been indentified. I have seen no specimens of *aurinia* or of any allied species from these mountains. Possibly *asiatica* may be a form of *alexandrina.*

The following forms of *Euphydryas aurinia* have been described :—

acedia *M. aurinia acedia* Fruhstorfer, 1916 (1917), *Arch. Naturg.* **82** (A) (2) : 7. Loc. Western England. The submedian spots are large, and the black markings are fine. See p. 460.

albofasciata *Euphydryas aurinia* ab. *albofasciata* Frohawk, 1938, *Var. Brit. Butt.* : 75 (Pl. 17, fig. 1). Name and figure only. On upper surface the discal field of the fore-wings is mostly white, and there are white macules also on the disc of the hind-wings.

alfacaria *M. aurinia* f. *alfacaria* Ribbe, 1910, *Iris* **23** : 132 (Beiheft). Loc. Andalusia. A form of *beckeri* Led. in which the upper surface is uniformly reddish-brown, without yellow and orange macules.

amasina *M. aurinia amasina* Bang-Haas, 1908, Seitz, *Grossschmett. Erde* **1** : 214. Loc. Asia Minor. Very near *sareptana*, but the colour contrast is less extreme. See p. 463.

anglicana *M. aurinia anglicana* Fruhstorfer 1916 (1917), *Arch. Naturg.* **82** (A) (2) : 6. Loc. Kent (England). With less contrast than *hibernica* Birchall, but more colour than German specimens. See p. 460.

apiciata *M. aurinia apiciata* Rober, 1926, *Ent. Mitt.* **15** : 228. Loc. Troitskowark, Baical. Near *mandschurica*, but the black pattern is stronger and the colours are more intense. Very near *tenebricosa* Bang-Haas.

artemis *Papilio artemis* Schiffermuller, 1775, *Wiener Verzeichniss* : 322. Loc. Frankfurt, Northern Germany. Orange-brown without yellow macules. See p. 460.

asiatica *M. aurinia Rott.* var. *asiatica* Staudinger, 1881, *Stett. ent. Ztg.* **42** : 287. Loc. Ala Tau Mountains. A small pale form, with characters intermediate between *aurinia* and the Alpine *debilis*. Underside brightly coloured. See p. 473.

atricolor *M. aurinia* ab. *atricolor* Schultz, 1906, *Eng. Z. Guben* **19** : 205. No locality given. Upper surface much darker than usual. Orange persists in submarginal band of hind-wings.

aurunca *M. aurinia aurunca* Turati, 1910, *Ent. Z. Guben* **23** : 223. Loc. Aurunci Mountains, Caserta, Italy. Strongly marked black pattern on upper surface, below as in *provincialis* Boisd. See p. 460.

balcanica *M. aurinia* var. *balcanica* Schawerda, 1908, *Jber. Wien. ent. Ver.* **1908** : 91. Loc. Vucijabara, Herzegowina. A large pale form close to *provincialis* Boisd. See p. 460.

banghaasi *M. aurinia banghaasi* Seitz, 1907, *Grossschmett. Erde* **1** : 214 Loc. Kentei Mountains. A small and very brightly coloured mountain form. See p. 473.

beckeri *Melitaea beckeri* Lederer, 1852 (1853), *Ver. zool.-bot. Ges. Wien* **2** : 39. Loc. Cadiz, southern Spain. (Name for H.-S. figures 1 and 2.) The large tawny Spanish form, with brilliant underside. See p. 464.

bicolor *M. aurinia* f. alp. *merope* Prun. f. *bicolor* Wehrli. Quoted without reference by Vorbrodt, 1928, *Dtsch. ent. Z. Iris* **42** : 20. Loc. Reported from Zermatt. A very dark form from the highest altitudes. (In *Nov. Macrolep.* **2** : 59, reference given to *Mitt. ent. Ver. Basel*, 1919.)

brunnea *M. aurinia* ab. *brunnea* Tutt, 1896, *Brit. Butterflies* : 316. Uniform tawny colour, resembling *M. cinxia* L. See p. 460.

bulgarica *M. aurinia bulgarica* Fruhstorfer, 1916 (1917), *Arch. Naturg.* **82** (A) (2) : 6. Loc. Rilo Mountains, Bulgaria. Specimens small and bright, with strongly developed black markings. See p. 460.

castillana *M. artemis castillana* Oberthur, 1909, *Études Lep. Comparée* **3** : 226. La Granja, Spain. Smaller and less brilliant than the *iberica* of Andalusia. See p. 464.

catherinei *M. aurinia* Rott. ab. *catherinei* Le Charles, 1924, *Amateur Pap.* **2** : 88. Loc. Romilly, Aube. The disc of the fore-wings black and all pattern much distorted.

comacina *M. aurinia comacina* Turati, 1910, *Ent. Z. Guben.* **23** : 223. With little colour contrast on upper surface, below very pale and markings are indistinct. Loc. above Lake Como. See p. 463.

davidi *M. artemis* var. *davidi* Oberthur, 1881, *Études d'Ent.* **6** : 52 (nota). Loc. Northern China. A large form with narrow wings, the ground-colour pale fawn. See *mandschurica* Staudinger. See p. 467.

debilis *M. artemis debilis* Oberthur, 1909, *Études Lep. Comparée* **3** : 228. Loc. Pyrénées Or. and Basses Alpes. The brightly coloured southern form of the small Alpine subspecies. See p. 469.

debilis-provincialis *M. aurinia* race *debilis-provincialis* Verity, 1928, *Ent. Rec.* **40** : 90. Loc. Gironde, France. Said to be intermediate between *debilis* Ob. and *provincialis* Boisd. The race appears to show no individual characters.

deficiens *M. aurinia* ab. *deficiens* Cabeau, 1928, *Lambillionea* **2** : 28. Loc. Hockai, Belgium. Pale ground-colour and indistinct markings.

demaculata *M. aurinia* var. *iberica* ab. *demaculata* Bubacek, 1923, *Verh. zool.-bot. Ges. Wien* **72** : 24. Loc. Andalusia. On the upper surface the median band of the hind-wings is reduced to small dots.

denigrata *M. aurinia comacina* ab. nov. *denigrata* Turati, 1919 (1920), *Nat. Siciliana* **23** : 221. Loc. Brunate (Como). The black median fascia is wanting on the fore-wings (Fig.).

diluta *M. aurinia* ab. *diluta* Heinrich, 1923, *Dtsch. ent. Z.* **1923** (Beiheft) : 48. Loc. Digne, France. The black pattern on the upper surface is very fine, partly obsolete.

dubia *M. aurinia* ab. *dubia* Krulikowsky, 1891, *Bull. Soc. Nat. Mosc.* **4** : 234. Loc. Casan, Russia. Smaller and paler than *sareptana* Stgr.

emba *M. aurinia emba* Fruhstorfer, 1916 (1917), *Arch. Naturg.* **82** (A) (2) : 7. Loc. Emba, Uralsk. Approaches *banghaasi* Seitz, but ground-colour is pure white instead of yellowish. See p. 473.

eothena *M. desfontainii eothena* Rober, 1926, *Ent. Mitt.* **15** : 228 Loc. Ussuri. Ground-colour lighter than usual. Described from a single female. Very near *davidi* Oberthur.

estonia *M. aurinia* var. *estonia* Petersen, 1902, *Beitr. Kunde Est.-, Liv.- und Kurlands* **142** : 6. Loc. Esthonia. A brightly coloured form with prominent yellow markings. The under surface is pale, but the markings are clearly defined.

frigescens *M. aurinia* race *frigescens* Verity, 1928, *Ent. Rec.* **40** : 45. Loc. Martigny. Said to be intermediate between *aurinia* and *glaciegenita* Vrty. See p. 471.

fulvacea *M. aurinia* Rott. ab. *fulvacea* Lambillion, 1911, *Rev. Mens. Namur.* **11** : 78. Loc. Virton. Usual discal and marginal yellow macules quite wanting. Ground-colour uniform tawny. See *brunnea* Tutt.

geminifasciata *M. aurinia* ab. *geminifasciata* Derenne, 1927, *Lambillionea* **27** : 11. Loc. Virton. On the under surface of the hind-wings the typical orange median fascia is extended by a yellow post-median band.

glaciegenita *M. aurinia* race *glaciegenita* Verity, 1928, *Ent. Rec.* **40** : 43. Loc. Stelvio Pass. Proposed as *nomen novum* pro *Papilio merope* auct. of the Central and Eastern Alps, as distinct from the southern race of Piedmont, named *merope* by de Prunner. See p. 471.

graciliens *M. aurinia* ab. *graciliens* Derenne, 1927, *Lambillionea* **27** : 10. Loc. Virton, Belgium. On the upper surface the wings are almost unicolorous and markings nearly obsolete.

hibernica *M. aurinia* var. *hibernica* Birchall, 1873, *Ent. mon. Mag.* **10** : 154. Loc. Mosses of Central Ireland. Name proposed for " the Irish form." This form shows brilliant colour contrast, with white and yellow macules on deep-black ground colour. (There is a reference to a plate which is wanting in all copies examined.) See p. 460.

iberica *M. artemis* var. *iberica* Oberthur, 1881, *Études d' Ent.* **6** : 54. Loc. Spain (Andalusia, Barcelona and Gibraltar). The largest and most brilliant Spanish race. See p. 464.

impunctata *M. aurinia* ab. *impunctata* Schultz, 1906, *Ent. Z. Guben* **19** : 205. Loc. Not given. Without black pupils in the submarginal fascia of the hind-wings. Most common in the female sex. Also in forma *merope* Prunn. (*debilis* Ob.) C. Vorbrodt, 1928, *Iris* **42** : 20.

infra-rectiangula *M. aurinia* ab. nov. *infra-rectiangula* Caruel, 1939, *Lambillionea* **39** : 46 (fig.). Loc. Marne. A pale rectangular macule in cellule 2 of hind-wings.

insterburgia *M. aurinia* ab. nov. *insterburgia* Braun, 1937, *Ent. Rundsch.* **54** : 556 (fig.). Loc. Germany. Strongly emphasised black band proximal to orange submarginal fascia of hind-wings.

koloswarensis *Papilio koloswarensis* Piller, 1783, *Iter Poseg.* : 41. Loc. Slavonia. Valid and available for a local race if required. Probably may be taken as a synonym of typical *aurinia*.

koreana *M. aurinia koreana* Collier, 1933, *Ent. Rundsch.* **50** : 54. Loc. Sei-Shin, Northern Korea. A form of *siberica* near *tenebricosa* Bang-Haas. The name is preoccupied by *M. aurelia koreana* Elwes, see *phyllis* Hemming. This form is described from a single male. See p. 467.

kricheldorffi *M. aurinia kricheldorffi* Collier, 1933, *Ent. Rundsch.* **50** : 54. Loc. Picos de Europa, Spain. Approaches *iberica* Ob., but smaller and the black markings more intense. See p. 464.

laeta *M. aurinia* var. *laeta* Christoph, 1893. Loc. Vilui River, Siberia. Near *merope* Prunn. (*debilis* Ob.), the macular series enlarged. See p. 465. This is not an obviously oriental form.

leucophana *M. aurinia* ab. *leucophana* Cabeau, 1928, *Lambillionea* **28** : 78. Loc. Belgium, Virton. The ground-colour of the fore-wings is almost white.

lye *Papilio lye* Bergstrasser, 1780, *Nomencl. Ins.* **4** : 28. Loc. Germany, Hanau. Valid and available. This is probably a synonym of *aurinia*.

maculata *M. aurinia* ab. *maculata* Bubacek. Ref. in Staudinger's Price-list, 1938. There is no description, and I cannot trace the reference. Probably misprint for *demaculata* Bub., 1923.

mandschurica *M. aurinia* var. *mandschurica* Staudinger, 1892, *Iris* **5** : 323. nec *M. athalia* var. *mandschurica* Fixsen, 1887. Loc. Upper Amur. A form with wide and deep black bands on the upper surface; the ground-colour is uniform reddish-yellow. It is probable that Staudinger's *mandschurica* is a synonym of *davidi* Oberthur, and no new name is required. See p. 467.

matutina *Papilio matutina* Thunberg, 1791, *Ins. Suecica* **2** : 31. Loc. Sweden. Valid and available for a local race if required.

merope *Papilio merope* de Prunner, 1798, *Lepidoptera Pedemontana* : 73. Piedmont. *nec P. merope* Fab., 1775. See *glaciegenita* Verity.

merope-minor *M. aurinia merope-minor* Kruger i.l. ref. in Vorbrodt and Muller-Rutz, 1916, *Mitt. schweiz. ent. Ges.* **12** : 435. Loc. Campolungo. A small form 24 mm.

minima *M. aurinia* var. *minima* Gianelli, 1890, *Ann. Acc. Agric. Torino* **33** : 199. Loc. Venaria Reale. A very small aberration.

morena *M. aurinia* forma *morena* Ribbe, 1910, *Iris* (Beiheft) **23** : 132. Loc. Sierra de Alfacar, Andalusia. The black markings extend across the yellow macules.

moritura *M. aurinia* race *moritura* Verity, 1928, *Ent. Rec.* **40** : 89. Loc. Susa and Turin. Rather pale and unicolorous specimens near *provincialis* Boisd. See p. 462.

namurcensis *M. aurinia* var. *namurcensis* Lambillion, 1911, *Rev. Mens. Namur* **11** : 78. Loc. Arguet (Namur). With uniform fulvous ground-colour. See *artemis* Fab., *fulvacea* Cabeau and *brunnea* Tutt.

nana *M. aurinia* ab. *nana* Rehfous, 1910, *Cat. Rhop. Genève* : 12. A dwarf form, exp. 26 mm. See also *minima* Gianelli.

nigrolimbata *M. aurinia* ab. *nigrolimbata* Schultz, 1906, *Ent. Z. Guben* **19** : 205. No locality specified. Wing-margins much wider than usual. Among the type form.

nigrolunulata *M. iberica* Ob. ab. *nigrolunulata* Fernandez, 1918, *Bol. Soc. ent. esp.* **1** : 158. A form similar to ab. *alfacaria* Ribbe, but the subterminal lunules are not yellow.

obscurata *M. aurinia* ab. *obscurata* Krulikowsky, 1890, *Bull. Soc. Nat. Mosc.* **4** : 235. Loc. Casan. The wings darkened above. A melanic aberration.

ochrea *M. aurinia* ab. *ochrea* Tutt, 1896, *Brit. Butt.* : 318. Loc. Not specified. All pale markings on the fore-wings ochreous with no trace of red. See p. 460.

pellucida *M. aurinia* var. *pellucida* Christoph, 1893, *Iris* **6** : 86. Loc. Eastern Caucasus. A small pale form. Figure and short note in Romanoff, 1897, *Mém. Lép.* **9** : 190, Pl. 14, fig. 3. See. p. 472.

perianthes *M. aurinia* ab. *perianthes* Cabeau, 1926, *Lambillionea* **26** : 74. Loc. Belgium. On the upper surface of the hind-wings the marginal border is dense black, marked with striking white macules. One ♂; one ♀.

phyllis *Eu. aurinia phyllis* Hemming, 1941, *Proc. ent. Soc. Lond.* (B) **10** : 207. Loc. Korea. Nom. nov. pro *M. aurinia koreana* Collier, 1933, *nec M. aurelia koreana* Elwes, 1899.

praeclara *M. aurinia* var. *praeclara* Kane, 1893, *Entomologist*, **26** : 159. Loc. Central Ireland. Vivid colours and velvet black markings. Ref. to Hubn. figs. 4, 5 and 6, but see *hibernica* Birchall, 1873. See p. 460.

provincialis *M. artemis provincialis* Boisd., 1828, *Index Method.* : 17. Loc. Provence. Large and with fulvous, not yellow, macules. See p. 461.

pseudomerope *M. aurinia pseudomerope* Vorbrodt, 1914, *Schmett. Schweiz.* **2** : 609. Loc. Elgg (540 m.). The upper surface is like *merope*, but pattern beneath much brighter.

pyrenes-debilis *M. aurinia* race *pyrenes-debilis* Verity, 1928, *Ent. Rec.* **40** : 90. Loc. Pyren. Orient. Resembles *debilis* Ob., but wings more thinly scaled, and on the under surface the pattern is less distinct. Should be treated as a synonym of *debilis* Ob. See p. 469.

rectiangula *M. aurinia* Rott. ab. *rectiangula* Cabeau, 1924, *Rev. mens. Soc. ent. Namur* **24** : 17. Loc. Belgium (Hockai). There is a large rectangular yellowish mark on the upper surface of the fore-wings.

rotunda *M. desfontainii rotunda* Rober, 1926, *Ent. Mitt.* **15** : 228. A large and pale form, very near to *provincialis* Boisd. See p. 462.

sareptana *M. artemis* var. *sareptana* Stgr., 1871, *Cat.* (Ed. 2) : 17. Loc. Sarepta, Pontus. More variegated on the upper surface. Paler below. Attributed to *orientalis* H.-S. by Staudinger in 1882. See p. 484.

sareptensis *M. aurinia* var. *sareptensis* Stgr., 1879, *Hor. Soc. ent. Ross.* **14** : 265. Loc. Sarepta. Probably an attempt to improve upon the earlier *sareptana* Stgr. See p. 462.

scotica *M. aurinia* var. *scotica* J. E. Robson, 1880, *Young Naturalist* **2** : 37. Resembles *hibernica* Birchall, but the colour contrast is less intense and the black pattern is dull. "Scotland." See p. 460.

scotica *M. aurinia scotica* Bang-Haas, 1930, Seitz, *Grossschmett. Erde* (Suppl.) : 204. Loc. Oban, Carlisle. The hind-wings with small round submarginal spots. Preocc. by *scotica* Robson.

sebaldus *M. aurinia* ab. *sebaldus* Schulz, 1906, *Ent. Z. Guben* **19** : 206. Loc. Not stated. The orange marginal line on under surface of hind-wings almost or quite missing.

semifuscata *M. aurinia* ab. *semifuscata* Cabeau, 1919, *Rev. mens. Soc. ent. Namur* **19** : 61. Loc. Belgium (Virton). The markings of the upper surface obscured by a general dark-brown suffusion.

sesostris *M. aurinia* ab. *sesostris* Schulz, 1906, *Ent. Z. Guben* **19** : 206. Loc. Dusseldorf and Berein. On the under surface of the hind-wings the basal yellow macules not developed.

siberica *M. artemis* var. *siberica* Staudinger, 1861, *Cat.* (Ed. 1) : 7. Loc. Not given. A name for *M. desfontainesii* Eversmann, *Ent. Ross.* **5** : 92 and fig. In *Cat.* (Ed. 2), locality given as Sib. Or. and Daurica. See p. 465.

signifera *M. aurinia* var. *signifera* Kane, 1893, *Entomologist* **2** : 158. Loc. Penarth, Wales. On upper surface the black reticulation is extensive. On hind-wing the red marginal band is prolonged inwards towards the wing base. This appears to be an aberrational form.

sterlineata *M. aurinia comacina sterlineata* Turati, 1920 (1919), *Nat. Siciliana* **31** : 221. Loc. N. Italy, Brunate (Como). The discal stripe of the fore-wing is absent. See also *M. phoebe sterlineata* Tur.

suffusa *E. aurinia* ab. *suffusa* Frowhawk, 1938, *Var. Brit. Butt.*, Pl. 17, fig. 3 (no text). Discal field of fore- and hind-wings uniform black.

tenebricosa *M. aurinia tenebricosa* Bang-Haas, 1927, *Hor. Macrolep.* **1**:51 and fig. Loc. Kansu. A dark form of *mandschurica*. See p. 467.

translucens *M. aurinia glaciegenita* forma *translucens* Verity, 1928, *Ent. Rec.* **40**:43. The extreme form of sparsely scaledfemales of *glaciegenita*.

tjutjujensis *E. aurinia tjutjujensis* nov. See p. 468.

transversa *M. aurinia* ab. *transversa* Cabeau, 1928, *Lambillionea* **11**:28. Loc. Belgium (Hockai). The fore-wings divided by a wide black median fascia. One male only.

turbida *M. aurinia* ab. *turbida* Gelin & Lucas, 1912, *Mém. Soc. Hist. nat. Deux-Sevres*: 34 (separate). A melanic form. *Cf.* Delahaye, *Cat. Lep. Maine et Loire.*

valentini *M. aurinia* var. *valentini* Nitsche, 1928, *Verh. zool.-bot. Ges. Wien* **78**:14. Loc. Valentin Alp in Plocken district, June/July, at 1204 m. A small form, slightly larger than *merope*, which it resembles below. Above, the colour contrast is marked.

virgata *M. aurinia* ab. *virgata* Tutt, 1896, *British Butterflies*: 318. No locality given. The discal and post-discal orange bands are united on the fore-wings. This central band is very conspicuous. See also *athalia virgata.*

volhynica *M. aurinia* Rott. var. *volhynica* Ksienschopolsky, 1911, *Werke Ges. Erf. Wolh.* **8**:38 (1912, *Trd. Obsc. izsl. Volhyni Zitomir* **8**:1–76). Not available for examination.

volupis *M. aurinia volupis* Fruhstorfer, 1919, *Arch. Naturg.* **83** (A) (3):167. Loc. Monte Lema, Tessin (Switzerland). See p. 463.

EUPHYDRYAS ALEXANDRINA Staudinger. Distribution Map 7.

M. aurinia var. *alexandrina* Staudinger, 1887, *Stettin. ent. Ztg.* **48**:52. Loc. Alexander Mts.

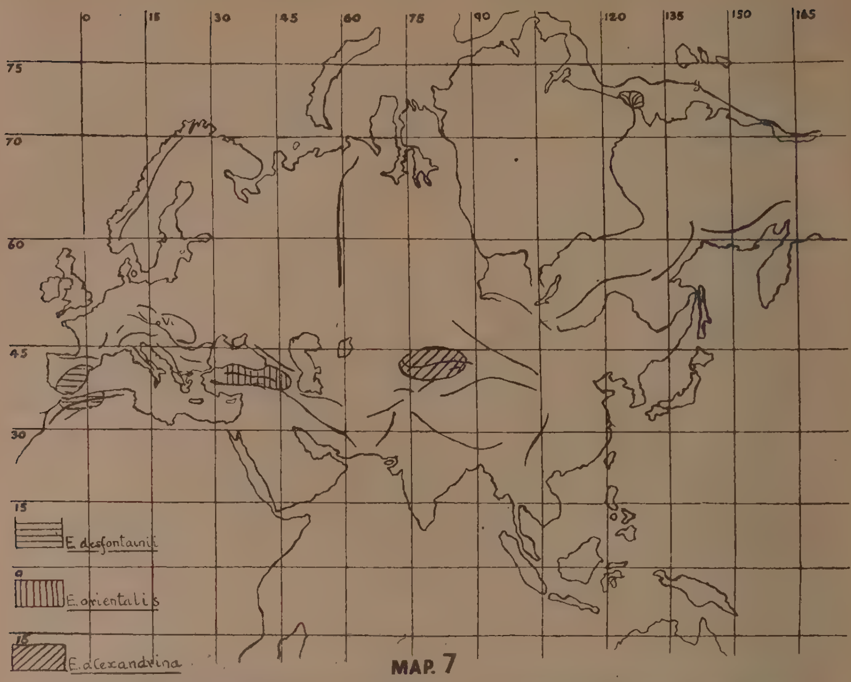
? *M. aurinia* var. *asiatica* Staudinger, 1881, *Stettin. ent. Ztg.* **42**:287. Loc. Ala-Tau.

M. aurinia var. *narina* Oberthur, 1909, *Études Lép. Comp.* **3**:230. Loc. Naryn, east Turkestan.

Fore-wing ♂ 17–19 mm., ♀ 18–20 mm.

In the typical form of this small species the ground-colour of the upper surface is distinctly reddish, the black markings not heavy. On the fore-wings the ground-colour is usually yellowish, and large yellow macules appear in the orange submarginal fascia. A black longitudinal mark is present in most examples in cellule 1, below the cell at the wing-base. On the hind-wings there is a dense black suffusion along the inner margin; distal to this the black markings are not prominent, and the black proximal margin of the wide orange submarginal fascia is often wanting. This gives a distinctive fascies to the majority of specimens. On the under surface the markings are distinct, but there is a good deal of pale whitish-yellow and rather a bleached appearance. On the fore-wings there is a wide interval between the end of the cell and the costal bar of the discal series. The female resembles the male, but is larger and the markings are often somewhat less well defined.

Variation and distribution. This insect closely resembles *aurinia*, but may be separated by the characters mentioned above. The distinctive features are easier to recognise than they are to define, and separation is not difficult. There seems to be the usual variability in different colonies. The typical form, described above, is probably confined to dry localities. I have many

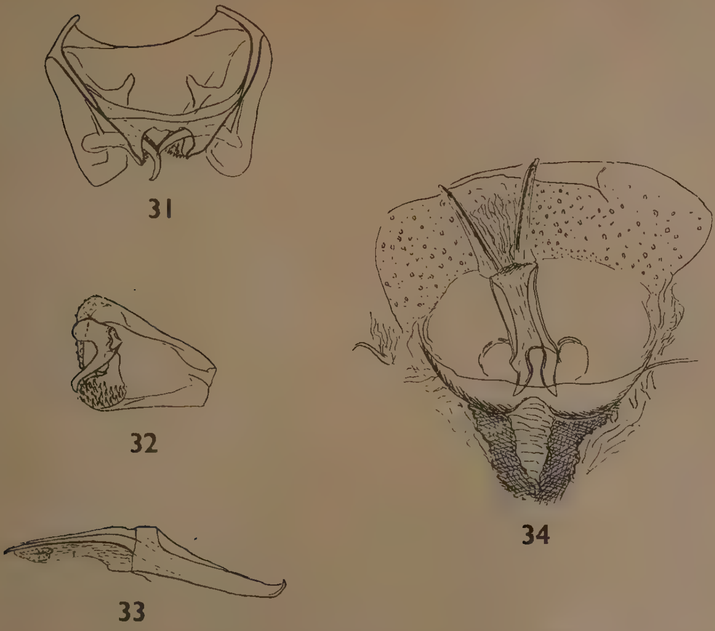


Map 7.—Distribution areas of *E. desfontainii* and *E. orientalis* in West and East Mediterranean areas respectively. The distribution area of *E. alexandrina* is isolated in Central Asia.

specimens in which the black markings on the upper surface of the fore-wings are very well developed. Those recorded below, from Tekkes, are particularly dark. The darkest specimens may be referred to *narina* Ob., and probably *asiatica* represents an intermediate form. At present I have seen no specimens from the Ala Tau, and its occurrence here cannot be accepted without further proof, but no form of true *aurinia* has been recorded from the district. The butterfly replaces *aurinia* in the western Thian Shan and related mountain ranges. It occurs there as an isolated member of the genus peculiar to the central Asiatic region, and the distribution is therefore unusual.

The genitalia (fig. 31) show considerable difference from those of *aurinia*. The whole structure is shorter and smaller. Seen from above the condyles are prominent and the harpe extends across the mid-line. In lateral view the clasp (fig. 32) is distinctly triangular, and the harpe not semicircular as in *aurinia*, but consisting of a stout upper limb and a much more slender lower limb. The aedeagus (fig. 33) is not so distinctive, but the two fusiform morulae are easily seen. The female genitalia (fig. 34) are of the *aurinia* type, with the bacilli shorter. The bare area is extensive and appears cupped.

Localities :—Alexander Mountains. No further data. (? Ala Tau, *fide* Staudinger.) Semirechensk ; Kuldja ; IssykKul ; Karagaitau, Narynsk ; Djarkent, Bossogo, 12,000 ft., July ; Tekes, 4500 ft., June.



FIGS. 31–34.—*Euphydryas alexandrina* Staudinger. 31. Male genitalia; 32. Clasp, showing harpe; 33. Aedeagus, lateral view; 34. Female genitalia.

EUPHYDRYAS DESFONTAINII Godart. Distribution Map 7.

Argynnis desfontainii Godart, 1819, *Ency. Méthod.* **9** : 278. Loc. Barbary (*i.e.* northern Africa).

Melitaea desfontainesi Boisduval, 1832, *Icones Lep.* **1** : 116. Loc. Barbary, Cadiz, Algiciras.

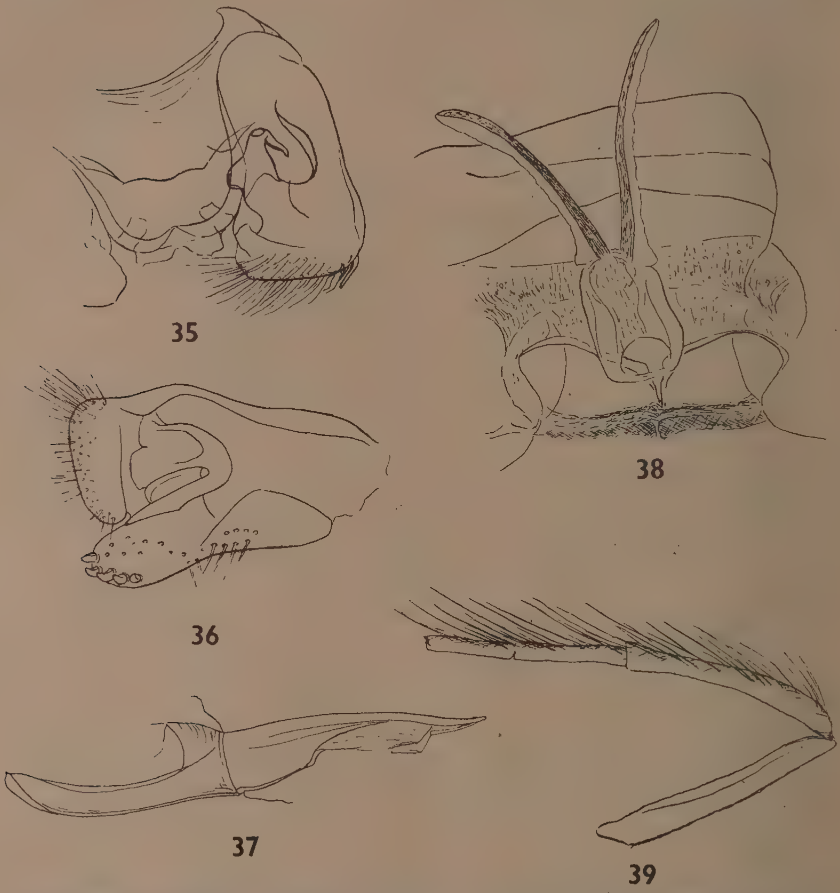
Melitaea desfontainesii Herrich-Schaeffer, 1852, *Europ. Schmett.* fig. 569/570. Text p. 1. Loc. Andalusia.

Fore-wing ♂ 21–25 mm., ♀ 23–26 mm.

In the male the fore-wing is wide and less pointed than in *aurinia*, with the outer margin gently convex to the anal angle. The upper surface resembles closely *aurinia beckeri* Led., and in some localities the two insects fly together, but *aurinia* appears a little later in the year. On the upper surface the markings are very bright, the ground-colour tawny-red, the black pattern intense, and the usual paler spots and macules yellowish. The margins of both wings are black, the marginal lines distinctly double and the lunules bright yellow, sharply angled and conspicuous against the black margin. On the under surface there is less resemblance to *aurinia*. The irregular markings extend to the inner margin and the black discal spots are well defined. On the hind-wing the basal orange fascia is broken up and is scarcely darker than the buff ground-colour. The marginal lunules and wing-border remain yellow with distinct traces of a double black terminal line. The female resembles the male but is usually larger (fig. 36).

The male genitalia (fig. 35) are large and very wide. Seen from above, the massive clasp (fig. 36) is almost quadrilateral, with the slender harpe curved strongly backwards. The usual spiny area is represented by six or seven strong and regular teeth at the posterior inferior angle. The aedeagus is nearly straight (fig. 37). A good figure is given by Ribbé in *Lep. Fauna Andalousie.* The female genitalia (fig. 38) show an exceptionally long bifid bacillus emerging from the short antrum. Compared with *aurinia* the scutum is greatly compressed.*

The early stages have been described carefully by H. Powell, from the Middle Atlas, where the larvae were found at elevations of 1700 to 2100 m., living upon *Knautia arvensis* Kock (*cf.* Oberthur, 1922, *Études Lép. Comp.* **19**: 48). The young larvae live in nests which are found upon various woody plants, *Thymus*, *Euphorbia*, etc. After a period of activity they aestivate during the summer heat, and do not become active again until the first rains in October, by which time they have probably reached the third stadium. Many larvae



Figs. 35–39.—*Euphydryas desfontainii* Godart. 35. Male genitalia, dorsal view; 36. Left clasp, showing harpe; 37. Aedeagus, lateral view; 38. Female genitalia; 39. Male fore-leg.

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* The male fore-tarsus is unusual in showing two joints, often prolonged (fig. 39).

die during the summer from drought, others are infested with *Apanteles* species. The surviving larvae pupate in March or early April. Powell found the first imagines near Mrassine on 12 April. In the later instars the larva is black, similar to that of *aurinia*, with very small white points scattered over the body. The pupa resembles that of *aurinia*, but the black macules on the wings are larger and discrete.

Variation and distribution. Individual variation appears on the usual lines, and consists in extension of the black markings, especially on the disc of the fore-wings, and in the replacement of the buff markings by clear yellow. This insect shows an interesting distribution around the western Mediterranean, which recalls that of *M. aetherie* Hb.. including central and southern Spain, Morocco and Algeria. A distinct but closely allied species, *E. orientalis* H.-S., appears in Asia Minor, and the two are so closely related that they may be regarded as vicariants. The original description of Godart specifies only " Barbary," *i.e.* northern Africa, as the locality. The careful descriptions of Oberthur make it suitable to specify as typical the form of western Algeria. He made a distinction between the Algerian form and that which is found further west in Morocco, which he names *gibrati* (1922, *Études Lép. Comp* **19** : 46). This is said to be larger and not quite so brightly coloured as the eastern form, but the difference is so slight that it is doubtful whether a special name is required. In Spain the butterfly occurs locally as far north as Barcelona, in a form which is usually smaller and paler, so that as a rule Spanish specimens can be distinguished from those from Africa. The Spanish forms show further differentiation, which is dealt with below.

Localities :—ALGERIA : Sebdou, Daya, El Hacaïba (all in Oberthur coll.).

Euphydryas desfontainii mod. ***gibrati*** Oberthur.

Melitaea desfontainii Godart var. *gibrati* Oberthur, 1922, *Études Lép. Comp.* **19** : 46 and figs· 4418/4422. Loc. Morocco, Zehroun Mountains.

Fore-wing ♂ 20–26 mm., ♀ 26–28 mm.

This form is represented by many specimens in the Oberthur collection. It is of large size, the fore-wings wide, and the colouring very bright. On the upper surface the heavy black markings show up well against the intense brick-red ground-colour, and the insects are distinctive when seen in series. The coloured figures given by Oberthur are excellent.

Localities :—MOROCCO : Massif de Zehroun, Mrassine, Douar de Garde, Timhadit, 22 April, 1935, 5000 ft. Ito, 18 April, 1935, 4000 ft. Azrou, 9 May, 1924, 2000 m. (Hartert and Young).

Euphydryas desfontainii mod. ***baetica*** Rambur.

Melitaea baetica Rambur, 1858, *Cat. Syst. Lepid. Andalousie* : 11, Pl. 1, figs. 3, 4.

Fore-wing ♂ 19–22 mm., ♀ 21–26 mm.

Andalusian specimens are usually smaller than those from Africa, but this distinction is not constant. On the upper surface the ground-colour is orange or yellow rather than red, and the black macules are often less prominent. On the under surface the fore-wings show a paler ground-colour, but the black markings are complete. On the hind-wings the black pattern is very thin, the black submarginal points much smaller. The whole wing is suffused with the greyish-yellow ground-colour, and the red marbling is almost or quite obsolete. These distinctions hold good for a long series in the British Museum and in my own collection, and the local characters appear to be very constant.

Locality :—SPAIN : Andalusia, Granada, Sierra de Alfacar, May. Ronda, May.

Ribbe points out that *baetica* flies when the larvae of *aurinia beckeri* begin to pupate. In Andalusia the larvae are found on a plant with blue flowers; they feed up during the summer and pass the winter as pupae, while *beckeri* hibernates as a small larva. He does not describe the larva of *baetica*, but he says it is quite unlike that of *beckeri*.

Euphydryas desfontainii mod. *zapateri* mod. nova.

Fore-wing ♂ 20–22 mm., ♀ 23 mm.

A series from Albarracin shows the fore-wings more pointed than in specimens from Granada and Ronda. On the upper surface the markings are normal. On the under surface the pattern is very clearly marked, especially on the hind-wings, where the macules and fasciae are clearly outlined with black. On the hind-wing the basal macules and submarginal fascia are reddish-orange, although the ground-colour is yellowish, so that there is marked colour contrast, and the black submarginal spots are large. These characters appear to be quite constant in specimens from Albarracin and Cuenca, and these specimens approach the typical form more closely than the *baetica* of the Sierra de Alfacar. Ribbé noted that the "typical form" occurred in Aragon and Castille, and no doubt he had noticed the special features of this race (*Beitrage Lep. Fauna Andalousie* : 133).

Holotype ♂, allotype ♀ and three ♂ paratypes in my collection.
Localities :—Castille ; Cuenca, Albarracin.

EUPHYDRAS ORIENTALIS Herrich-Schaeffer.

Melitaea orientalis Herrich-Schaeffer, 1845 (*teste* Sherborne), *Europ-Schmett.* figs. 265/266. Text **6** : 1. Loc. Amasia.

M. aurinia var. *sareptana* Staudinger, 1871, *Cat.* (Ed. 2) : 17 (*sareptana* Staudinger, 1861, *Cat.* (Ed. 1) : 8 is *nomen nudum*).

Fore-wing ♂ 19–23 mm., ♀ 21–26 mm.

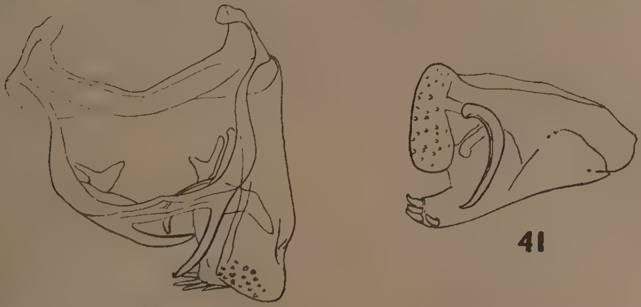
Slightly smaller than *desfontainii*, but all markings very similar. On the upper surface the ground-colour and yellow macules are paler in tone, and the black markings finer. The double terminal lines remain definitely black in both wings. The orange submarginal fascia is narrower, especially on the fore-wing. On the under surface the general tone is paler, with greater contrast on the hind-wing from orange to pale yellow. The yellow marginal lunules are a little wider and deeper than in *desfontainii*.

The male genitalia (fig. 40) resemble those of *desfontainii*. The tegumen is little developed, but there are two long subuncal processes. The clasp (fig. 41) shows the usual tuberculated area, and the posterior process carries five or six strong teeth, but is rather more slender than in *desfontainii*. The harpe is sickle-shaped, very similar to that of *aurinia*.

The female genitalia have not been examined.

The superficial resemblance between this species and *desfontainii* is so close that it is difficult to point to any feature, apart from the brighter colouring, which will allow a distinction between the two. This is the more astonishing since in Asia Minor, in the distribution area of *orientalis*, *aurinia* shows parallel variation and produces the brightly coloured *sareptensis*, with exactly the same colour-scheme. We must suppose that ecological conditions in this district promote colour contrast of this type. In spite of the well-differentiated genitalia it is reasonable to regard *desfontainii* and *orientalis* as vicarious species representing a single oriental stock established around the Mediterranean.

Localities :—ASIA MINOR : Amasia, Malatia, Mount Karadja. Argana Maden is given by Staudinger as the locality where Kinderman caught the original specimens described by Herrich-Schaeffer. Kedos, " Persia."



FIGS. 40, 41.—*Euphydryas orientalis* H.-S. 40. Male genitalia, dorsal view ; 41. Clasp, showing harpe.

Genus EUPHYDRYAS Scudder.

Check List of Species.

I. *MATURNA* GROUP. HOLARCTIC.

Palaearctic Species.

1. *maturna* Linnaeus, 1758.
    ab. *diabolus* Schawerda, 1914.
    ab. *fulgida* Schultz, 1908.
    ab. *kautzi* Schawerda, 1913.
    ab. *schlumbergeri* Schultz, 1907.
    mod. *staudingeri* Wnukowsky, 1929. (? forma *tempestatis*.)
    mod. *idunides* Fruhstorfer, 1917. (? forma *tempestatis*.)
    mod. *urbani* Hirschke, 1901.
2. *iduna* Dalman, 1816.
    ab. *sulitelmica* Schultz, 1920.
    mod. *sajana* nov.
3. *intermedia* Ménétriés, 1859.
    mod. *Konumensis* Matsumura, 1927.
    s.sp. *wolfensbergeri* Frey, 1880.
4. *cynthia* Schiffermüller, 1775.
    mod. *leonhardi* Fruhstorfer, 1917. (? forma *tempestatis*.)
    mod. *alpicola* Galvagni, 1918. (? forma *tempestatis*.)
    mod. *spuleri* Rober, 1926.
    ab. *aurinoides* Kiefer, 1918.
    ab. *brunneomarginata* Kiefer, 1912.
    ab. *fasciata* Wehrli, 1920.
    ab. *impunctata* Hoffman, 1911.
    ab. *leucophryne* Ochsenheimer, 1816.
    ab. *mundata* Turati & Verity, 1910.
    ab. *obscurior* Hofer, 1920.

ab. *privata* Stauder, 1922.
ab. *tricolor* Schawerda, 1926.
ab. *umbrata* Galvagni, 1918.

Nearctic Species.

The five nearctic species of the genus were reviewed by J. D. Gunder in 1929, and for the sake of completeness I have included his check-list as it was published then. The subspecific categories used in this list include race, form and intermediate form, but no forms are specified as subspecies (1929, *Pan-Pac. Ent.* **6** : 1–8).

5. *phaeton* Drury.
6. *chalcedona* Doubleday & Hewitson.
    a. *colon* Edwards.
    b. *wallacensis* Gunder.
    c. *perdiceas* Edwards.
    d. *mcglashanii* Rivers.
    e. *sierra* Wright.
    f. *olancha* Wright.
    g. *quino* Behr.
7. *anicia* Doubleday & Hewitson.
    a. *helvia Scudder.*
    b. *eurytion* Mead.
    c. *capella* Barnes.
    d. *bernadetta* Leuss.
    e. *maria* Skinner.
    f. *carmentis* Barnes & Benjamin.
    g. *magdalena* Barnes & McDunnough.
    h. *alena* Barnes & Benjamin.
    i. *wheeleri* Hy. Edwards.
    j. *morandi* Gunder.
    k. *hermosa* Wright.
    l. *irelandi* Gunder.
8. *editha* Boisduval.
    a. *wrighti* Gunder.
    b. *augusta* Edwards.
    c. *monoensis* Gunder.
    d. *rubicunda* Hy. Edwards.
    e. *nubigena* Behr.
    f. *aurilacua* Gunder.
    g. *baroni* Edwards.
    h. *edithana* Strd. ?
    i. *colonia* Wright.
    j. *taylori* Edwards.
    k. *beani* Skinner.
    l. *hutchinsi* McDunnough.
    m. *lehmani* Gunder.
9. *gillettii* Barnes.

II. *AURINIA* GROUP.

All Species Palearctic.

10. *aurinia* von Rottemburg, 1775.
    mod. *acedia* Fruhstorfer, 1917.
    ab. *albofasciata* Frohawk, 1938.

ab. *alfacaria* Ribbe, 1910. Referable to *beckeri* Led.
mod. *amasina* Bang-Haas, 1908.
mod. *anglicana* Fruhstorfer, 1917.
mod. *artemis* Schiffermüller, 1775. Colour form.
asiatica Staudinger, 1881. Not identified.
ab. *atricolor* Schultz, 1906.
mod. *aurunca* Turati, 1910.
mod. *balcanica* Schawerda, 1908.
mod. *beckeri* Lederer, 1853.
mod. *brunnea* Tutt, 1896. Colour form.
mod. *bulgarica* Fruhstorfer, 1917.
mod. *castillana* Ob., 1909.
ab. *catherinei* Le Charles, 1924.
mod. *comacina* Turati, 1910.
ab. *deficiens* Cabeau, 1928.
ab. *demaculata* Bubacek, 1923. Referable to *beckeri* Led.
ab. *denigrata* Turati, 1920.
ab. *diluta* Heinrich, 1923.
mod. *dubia* Krulikowsky, 1891.
mod. *estonia* Petersen, 1902.
mod. *frigescens* Verity, 1928. (Possibly referable to *debilis* Ob.)
ab. *fulvacea* Lambillion, 1911.
ab. *geminifasciata* Derenne, 1927.
ab. *graciliens* Derenne, 1927.
mod. *hibernica* Birchall, 1873, forma *tempestatis*.
ab. *impunctata* Schultz, 1906.
ab. *infra-rectiangula* Caruel, 1939.
ab. *insterburgia* Braun, 1937.
mod. *kricheldorffi* Collier, 1933.
mod. *laeta* Christoph, 1893.
mod. *leucophana* Cabeau, 1928.
ab. *minima* Gianelli, 1890.
ab. *morena* Ribbe, 1910. Referable to *beckeri* Led.
mod. *moritura* Verity, 1928.
ab. *nigrolimbata* Schultz, 1906.
ab. *nigrolunulata* Fernandez, 1918.
ab. *obscurata* Krulikowsky, 1890.
ab. *ochrea* Tutt, 1896. Colour form.
ab. *perianthes* Cabeau, 1926.
mod. *provincialis* Boisduval, 1828.
mod. *pseudomerope* Vorbrodt, 1914.
ab. *rectiangula* Cabeau, 1924.
mod. *rotunda* Rober, 1926.
mod. *sareptana* Staudinger, 1871.
sareptensis Standinger, 1879.
mod. *scotica* Robson, 1880.
ab. *sebaldus* Schultz, 1906.
ab. *semifuscata* Cabeau, 1919.
ab. *sesostris* Schultz, 1906.
ab. *signifera* Kane, 1893.
ab. *sterlineata* Turati, 1920.
ab. *suffusa* Frohawk, 1938.
ab. *turbida* Gelin & Lucas, 1912.
mod. *valentini* Nitsche, 1928.

ab. *virgata* Tutt, 1896.
volhynica Ksienschopolsky, 1911. Not available for examination.
mod. *volupis* Fruhstorfer, 1919.
s.sp. *siberica* Staudinger, 1861.
mod. *davidi* Oberthur, 1881.
mod. *tenebricosa* Bang-Haas, 1927.
mod. *tjutjujensis*, nova.
s.sp. *debilis* Oberthur, 1909.
ab. *bicolor* Wehrli, 1928.
mod. *glaciegenita* Verity, 1928.
ab. *merope-minor* Vorbrodt, 1916.
ab. *translucens* Verity, 1928.
s.sp. *bang haasi* Seitz, 1908.
mod. *emba* Fruhstorfer, 1917. Referred doubtfully to *bang haasi*.
11. *alexandrina* Staudinger, 1887.
mod. *narina* Oberthur, 1909.
12. *desfontainii* Godart, 1819.
mod. *gibrati* Oberthur, 1922.
mod. *baetica* Rambur, 1858.
mod. *zapateri* nova.
13. *orientalis* Herrich-Schaeffer, 1845.

SUMMARY.

1. The specific units which compose the genus *Euphydryas* are defined, with descriptions of all known Palearctic subspecies and modifications. All bibliographic references have been checked, and it is hoped that these are accurate and complete.

2. The geographical distribution of the species is indicated with the greatest possible accuracy. Distribution maps are included, which show several interesting examples of discontinuous distribution which occur in the genus.

3. Line drawings of the male and female genitalia are shown with the specific descriptions.

APPENDIX.

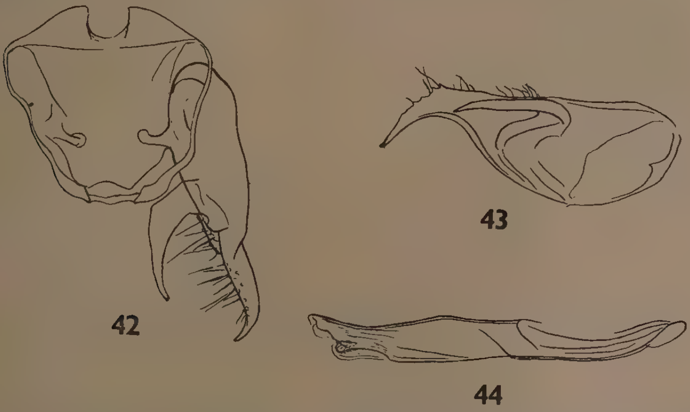
A Note on *Melitaea avinovi* Sheljuzhko.

Melitaea arduinna mod. *avinovi* Sheljuzhko, 1914, *in* Higgins, 1941, *Trans. R. ent. Soc. Lond.* **91** : 277.

Fresh specimens of this insect have become available and it is clearly a distinct species. Sheljuzhko's types came from the Pamirs, but the other specimens are from Afghanistan, which suggests an extensive distribution. No doubt the flight places are very localised. I have been able to give a more comprehensive description and figures of the male genitalia.

Fore-wing ♂ 17–18 mm., ♀ 21 mm.

On the upper surface this species resembles *arduinna*, but it is smaller. In the male the fore-wings are narrow, and the apex more pointed. The usual marks are present in the cell. The discal series is boldly marked, and anteriorly the macules are fused to form a prominent bar which is set obliquely to the costa. Beyond this area are a few traces of a post-discal series. The orange submarginal lunules are complete, and those in cellules 2 and 3 are exaggerated. On the hind-wings the usual markings are present, and a discal series of black macules is just indicated in three specimens. Four small black points are present in the post-discal fascia in cellules 1 to 4, all set very close to the submarginal lunules, of which that in cellule 3 is exaggerated. On the under surface the resemblance to *arduinna* is again very close, but there is one obvious difference in the black discal macule in cellule 1 of the fore-wing. If present at all in *avinovi* this is rounded and solid, but in *arduinna* it is usually shaped as a **V** with the apex pointing to the wing-base. The female resembles the males, but the markings are more complete, and the black marginal borders of all wings are conspicuously wide. There is a yellow flush on the fore-wings distal to the costal bar, and this colour is vaguely indicated also in the cell. Traces of this can be seen also in one male specimen. The colour variation is more obvious in the paratype obtained from Sheljuzhko, which is illustrated on Pl. 8, fig. 4 in my Catalogue.



Figs. 42–44.—*Melitaea avinovi* Shelj. 42. Male genitalia, dorsal view ; 43. Clasp, medial view ; 44. Aedeagus, dorsal view. All from Pamirs.

Specimens now in the collection at the British Museum are as follows :—

S.W. Pamirs : Ishkashim, one male paratype received from Sheljuzhko. Four ♂♂, one ♀, Paghman, 17 miles west of Kabul at 3000 ft., June, 1939. (*Chaworth Musters*).

The male genitalia are close to those of *arduinna*. In dorsal view (fig. 42), in the specimen dissected, the posterior process of the clasp is evenly curved, and does not show the series of teeth which appear in *arduinna*. The harpe is strong, directed posteriorly, and is much straighter than that of *arduinna*. In lateral view (fig. 43) of the clasp a few small teeth can be seen upon the superior margin of the posterior process, and the harpe runs directly backwards. The aedeagus is very similar to that in *arduinna*.

The female genitalia have not been examined.

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ERRATA.

P. 152, line 9, *for* " *varigata* " *read* " *variegata*."
P. 156, legend fig. 7, *for* " *clavata* " *read* " *claviata*."
P. 178, Summary, line 11, *for* " *mauru* " *read* " *maura*."

ADDENDUM.

Transactions, 1949, *Vol*. 100, *Part* 2.

Roepke, W. The genus *Nyctemera* Hübner.

P. 51, Paragraph 2 (*Nyctemera baulus*).

M. Bourgogne, of the Paris Museum, has pointed out that in the old captures of Dumont d'Urville four species of *Nyctemera* were found, among them the types of three species, viz., *baulus* Boisd. (1 specimen), *artemis* Boisd. (1 specimen), N. Guinea, and *annulatum* Boisd. (2 specimens), N. Guinea. He adds that the type of *baulus* (♀) corresponds " très exactement " with the figure of *baulus* (♂) on Pl. 1, fig. 2, so that the rediscovery does not affect the nomenclature.